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Vol. V

DEFENDANTS' EXHIBITS

Supreme Court of the United States

OCTOBER TERM, 1934

No. 255

ALTOONA PUBLIX THEATRES, INC.,
PETITIONERS,

vs.

AMERICAN TRI-ERGON CORPORATION AND TRI-ERGON HOLDING, A. G.

No. 256

WILMER & VINCENT CORPORATION AND LOCUST STREET REAL ESTATE COMPANY, PETITIONERS,

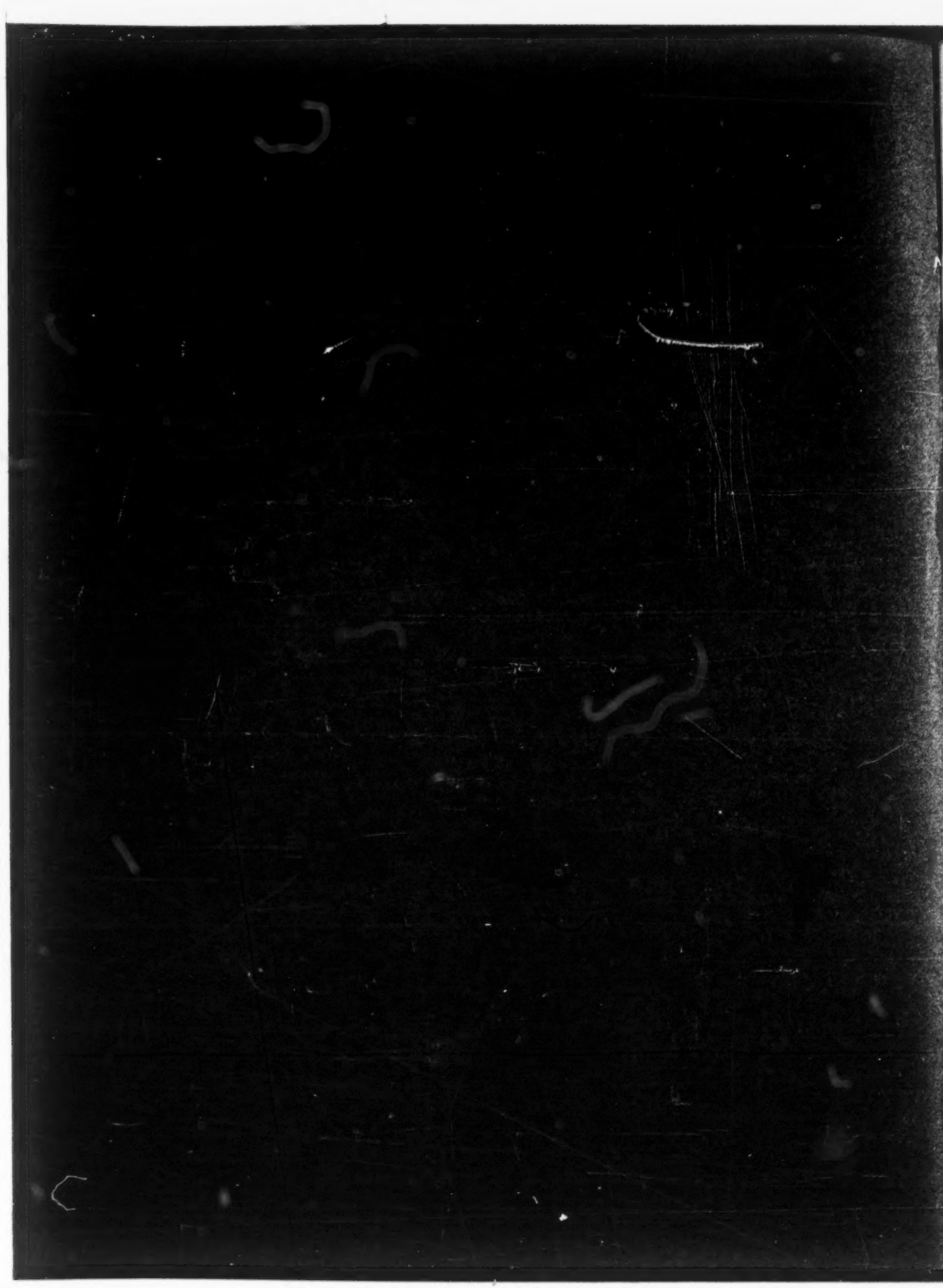
vs.

AMERICAN TRI-ERGON CORPORATION AND TRI-ERGON HOLDING, A. G.

ON WRITS OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE THIRD CIRCUIT

PETITION FOR CERTIORARI FILED AUGUST 4, 1934.

CERTIORARI GRANTED NOVEMBER 5, 1934.



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L. A. COLLINS.

METHOD OF AND APPARATUS FOR THE REPRODUCTION OF SOUNDS AND MOTIONS.

APPLICATION FILED MAY 26, 1917.

1,366,446.

Patented Jan. 25, 1921.

2 SHEETS—SHEET 1.

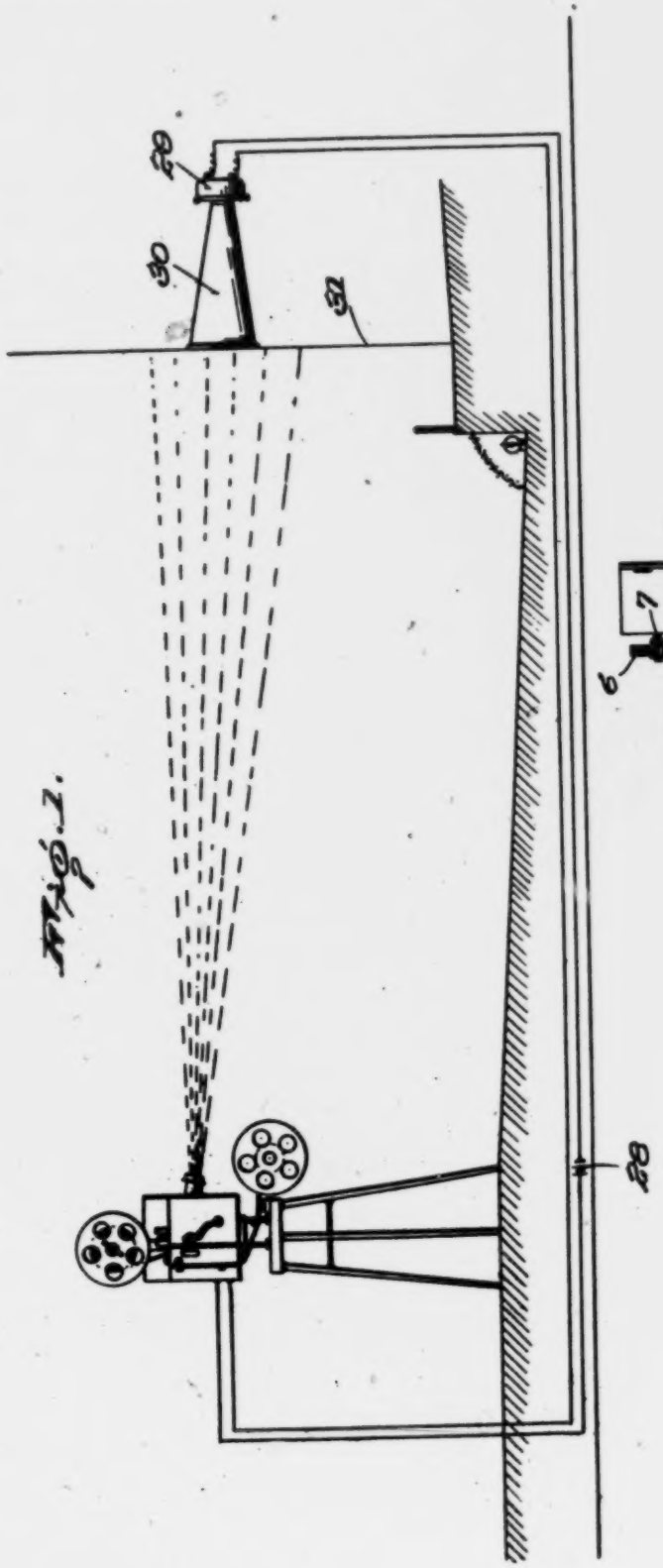

Fig. 1.

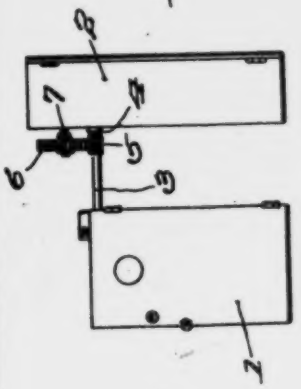

Fig. 2.

INVENTOR

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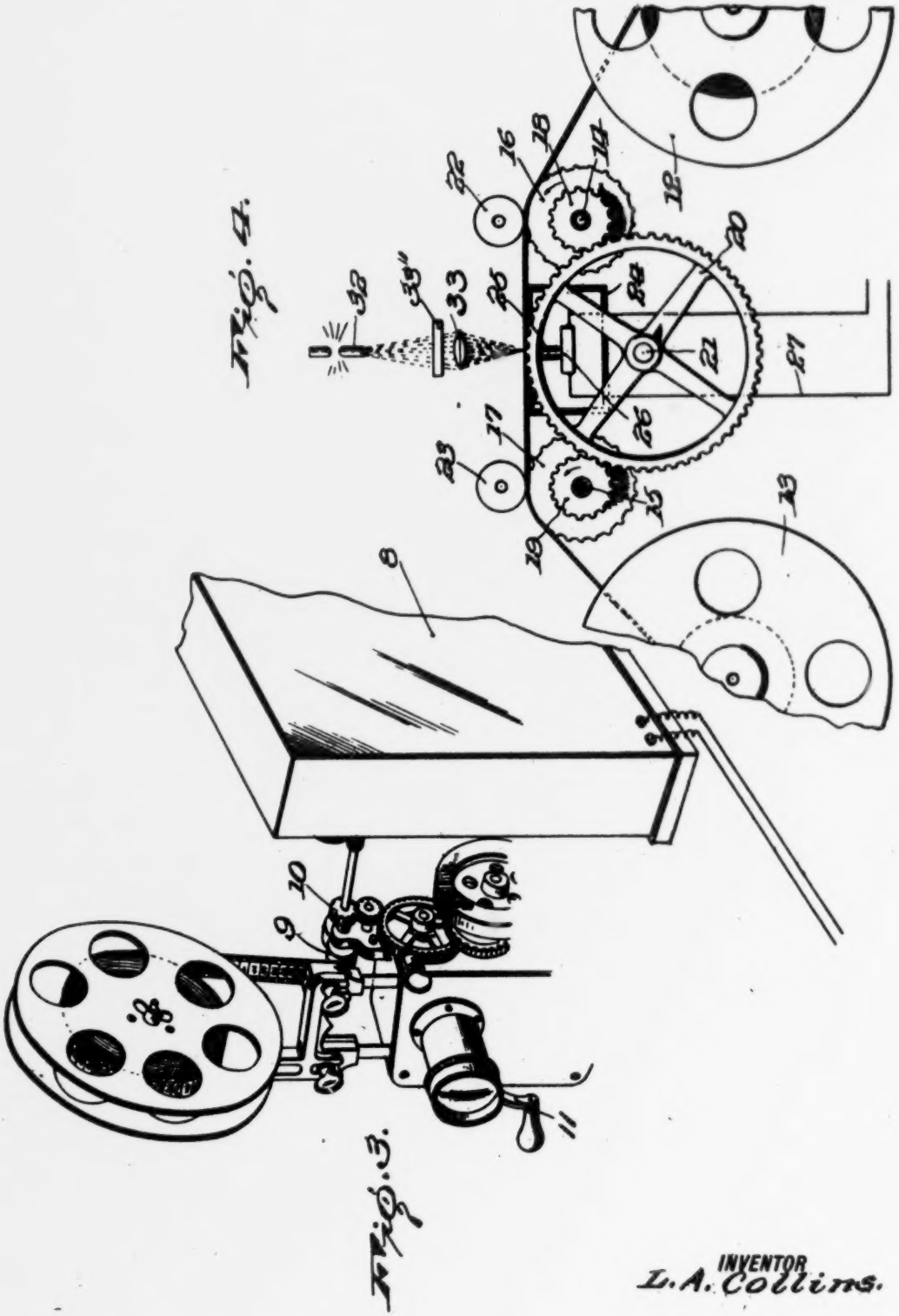
1150

L. A. COLLINS.

METHOD OF AND APPARATUS FOR THE REPRODUCTION OF SOUNDS AND MOTIONS.

1,366,446. APPLICATION FILED MAY 26, 1917. Patented Jan. 25, 1921.

2 SHEETS—SHEET 2.



INVENTOR
L. A. Collins.

BY

UNITED STATES PATENT OFFICE.

LEE A. COLLINS, OF LOUISVILLE, KENTUCKY.

METHOD OF AND APPARATUS FOR THE REPRODUCTION OF SOUNDS AND MOTIONS.

1,366,446. Specification of Letters Patent. Patented Jan. 25, 1921.

Application filed May 26, 1917. Serial No. 171,260.

To all whom it may concern:

Be it known that I, LEE A. COLLINS, a citizen of the United States, residing at Louisville, in the county of Jefferson and State of Kentucky, have invented certain new and useful Improvements in Methods of and Apparatus for the Reproduction of Sounds and Motions, of which the following is a specification.

This invention has as its object a novel method of and apparatus for the simultaneous reproduction of sound and picture records. Various methods have been proposed for the reproduction of picture and sound records in synchronism so that the exhibition of scenes would be accompanied by related sounds. It has been found impractical, however, to produce the desired results through the use of a purely mechanical means. For example, one method which has been tried but without success consists in the operation of a phonograph in conjunction with a motion picture projection machine. However, as phonograph records seldom, if ever, require more than eight minutes for their reproduction it becomes necessary to stop the operation of the projection machine in order to bring a new record into use, thus detracting from the faithfulness of the reproduction of the picture and sound records. Furthermore, in this method of reproducing picture and sound records it is practically impossible to operate the two reproducing means, namely the motion picture projection machine and the phonograph, in synchronism and it therefore not infrequently happens that when a certain scene is being projected the sounds at that time being reproduced by the phonograph will not relate to that particular scene or action but to some other scene or action. Even where the two machines are coupled for operation in unison this disadvantage is liable to present itself for the reason that films are frequently patched and in patching a film it is customary to cut out and discard a greater or less length of the film and if there are several patches in such a film the phonograph will, of course, run considerably behind the projection machine. Even where an unpatched film is employed it is practically impossible to start the two machines upon which the images are projected, whereas the motion picture projection apparatus is located a distance from the screen and it is, therefore, necessary to provide shafting and gearing mechanically connecting the two machines and extending beneath the floor of the theater or hall in which the machines are employed. Furthermore, in this method of reproduction of picture and sound records two operators are required, one for each machine, and it is an extremely difficult matter to so place the phonograph record upon the mandrel or revolving table and at the same time so thread the film into the projection machine that the sounds will be reproduced at the proper moment. It is, therefore, an aim of the present invention to provide a method of and apparatus for the reproduction of motion picture and related sound records in perfect synchronism.

The present invention contemplates the production, by any suitable method of a negative sound record from which may be printed, upon a photographically sensitized medium, a corresponding record which may be then employed in conjunction with the motion picture projection machine to reproduce the related sounds in synchronism with the projection of the motion pictures. Various methods may be employed in producing the negative record. For example, a photographically sensitized film corresponding to the ordinary film employed in motion picture cameras and projection apparatus, may be passed across a slit through which the rays from an electric light or the sun pass to the said film, a sound operated shutter being placed between the source of light and the said slit or where an electric light is employed a telephone transmitter may be placed in circuit therewith. This film is then developed in the usual manner and other films are printed therefrom and are employed by the method and in the apparatus embodying the present invention to reproduce the sound records. If desired instead of photographically printing the record from a negative film on to a sound film, the record may be printed upon an opaque strip of paper or other material photographically sensitized

L. A. COLLINS.

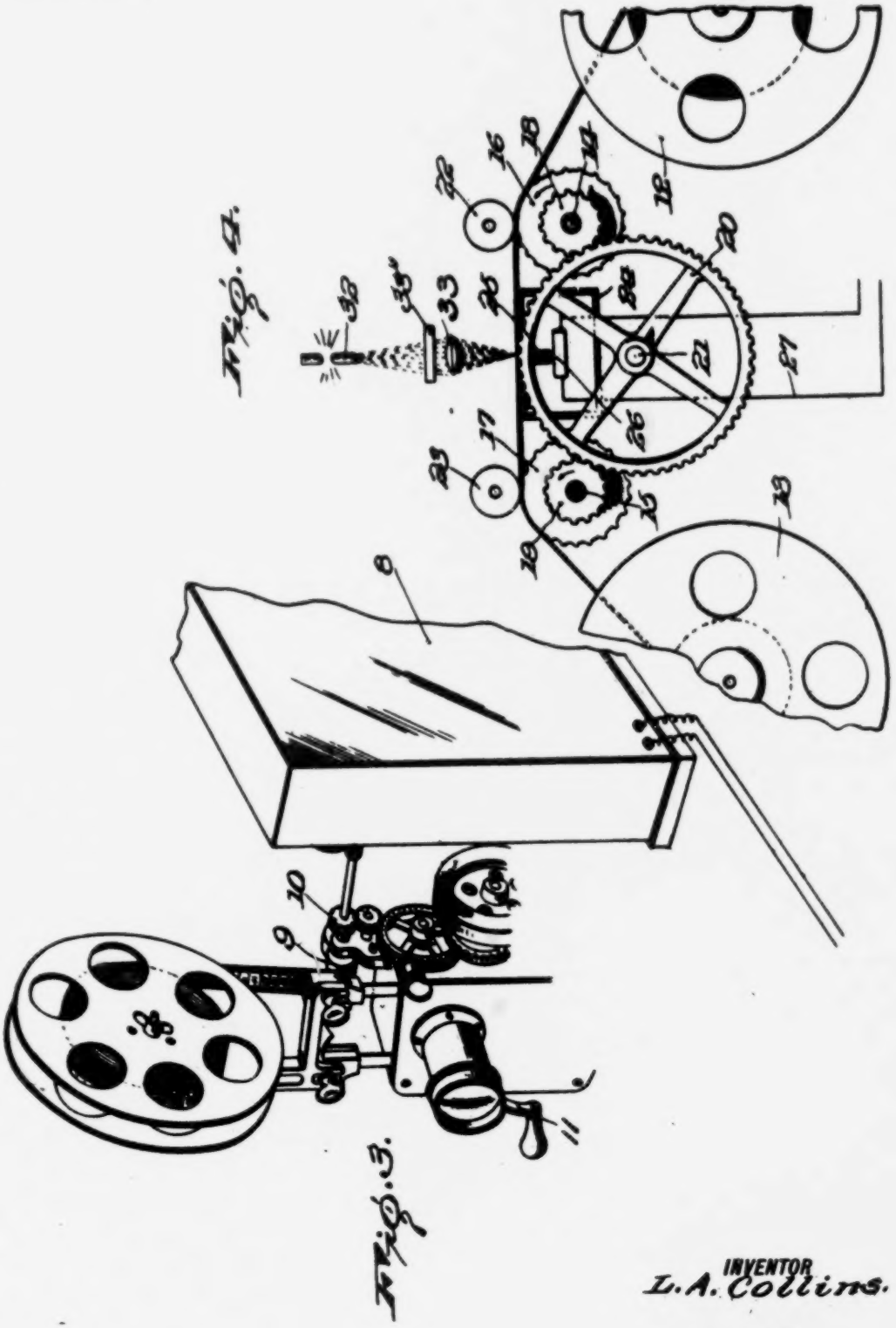
METHOD OF AND APPARATUS FOR THE REPRODUCTION OF SOUNDS AND MOTIONS.

APPLICATION FILED MAY 28, 1917.

1,366,446.

Patented Jan. 25, 1921.

2 SHEETS—SHEET 2.



INVENTOR
L. A. Collins.

BY
ATTORNEY

LEE A. COLLINS, OF LOUISVILLE, KENTUCKY.

METHOD OF AND APPARATUS FOR THE REPRODUCTION OF SOUNDS AND MOTIONS.

1,366,446. Specification of Letters Patent. Patented Jan. 25, 1921.

Application filed May 26, 1917. Serial No. 171,260.

To all whom it may concern:

Be it known that I, LEE A. COLLINS, a citizen of the United States, residing at Louisville, in the county of Jefferson and State of Kentucky, have invented certain new and useful Improvements in Methods of and Apparatus for the Reproduction of Sounds and Motions, of which the following is a specification.

This invention has as its object a novel method of and apparatus for the simultaneous reproduction of sound and picture records. Various methods have been proposed for the reproduction of picture and sound records in synchronism so that the exhibition of scenes would be accompanied by related sounds. It has been found impractical, however, to produce the desired results through the use of a purely mechanical means. For example, one method which has been tried but without success consists in the operation of a phonograph in conjunction with a motion picture projection machine. However, as phonograph records seldom, if ever, require more than eight minutes for their reproduction it becomes necessary to stop the operation of the projection machine in order to bring a new record into use, thus detracting from the faithfulness of the reproduction of the picture and sound records. Furthermore, in this method of reproducing picture and sound records it is practically impossible to operate the two reproducing means, namely the motion picture projection machine and the phonograph, in synchronism and it therefore not infrequently happens that when a certain scene is being projected the sounds at that time being reproduced by the phonograph will not relate to that particular scene or action but to some other scene or action. Even where the two machines are coupled for operation in unison this disadvantage is liable to present itself for the reason that films are frequently patched and in patching a film it is customary to cut out and discard a greater or less length of the film and if there are several patches in such a film the phonograph will, of course, run considerably behind the projection machine. Even where an unpatched film is employed it is practically impossible to secure perfect synchronism in the operation of the two machines by the employment of a mechanical connecting means for the phonograph must be placed back of or adjacent to the screen upon which the images are projected, whereas the motion picture projection apparatus is located a distance from the screen and it is, therefore, necessary to provide shafting and gearing mechanically connecting the two machines and extending beneath the floor of the theater or hall in which the machines are employed. Furthermore, in this method of reproduction of picture and sound records two operators are required, one for each machine, and it is an extremely difficult matter to so place the phonograph record upon the mandrel or revolving table and at the same time so thread the film into the projection machine that the sounds will be reproduced at the proper moment. It is, therefore, an aim of the present invention to provide a method of and apparatus for the reproduction of motion picture and related sound records in perfect synchronism.

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blade acted upon by a diaphragm vibrated by sounds striking the same. In this manner, of course, a record will be produced corresponding to the negative record produced upon the photographic film and a print may be made therefrom upon a sensitized film in the same manner as above explained. In fact, a record could be made by employing a vibratory impression element supplied with ink or other substance designed to apply a coating, to a transparent film, of a greater or less width according to the degree of vibration and prints could be made photographically from a record thus produced, upon a photographically sensitized film. Another method which may be followed, consists in providing a telephone receiver with a mirrored diaphragm which is presented toward the slit and over the film. A steady light is thrown on to the mirrored diaphragm and the sounds, collected by a telephone transmitter in circuit with the said receiver, will cause the mirrored diaphragm of the said receiver to vibrate thereby causing variations in the intensity of the light rays reflected on to the film. The methods above briefly described employ a strip or film as will be noted. However, inasmuch as it has been proposed to take and project motion pictures through the employment of a revolving glass disk upon which the picture records are photographically impressed, the present invention contemplates the employment, in such event, of a similar sound record. Assuming that the sound record is produced by photographically impressing the record upon a sensitized film such as employed in a motion picture camera, the film feeding mechanism for the camera and the film feeding mechanism for the sound recording apparatus are more or less directly connected for operation in unison and in preparing the two mechanisms for use their respective films are threaded therein and operation of the camera mechanism will result in operation of the sound recording mechanism in synchronism therewith. Thus the sounds are recorded in exact synchronism with the related scenes or acts and positive films prepared from the two negative film records thus produced may be employed in a similar arrangement of a projection apparatus and sound reproducing apparatus to cause reproduction of the two records in synchronism.

The invention also, as before stated, contemplates the provision of an apparatus for reproducing the picture and sound records in synchronism.

In the accompanying drawings:

cally a motion picture camera and a sound recording mechanism coupled for simultaneous operation;

Fig. 3 is a perspective view of a motion picture projecting machine and the sound reproducing apparatus embodying the invention;

Fig. 4 is a view in side elevation of the apparatus removed from its casing.

In Fig. 2 of the drawings there is illustrated diagrammatically a motion picture camera indicated by the numeral 1 and there is also shown in the said figure the casing for the sound recording apparatus, indicated in general by the numeral 2. The numeral 3 indicates a shaft which is connected with and driven from any suitable rotary element of the camera mechanism and which at its outer end seats in a bearing 4 upon a side of the casing 2 for the sound recording mechanism. A gear or pinion 5 is fixed upon the shaft 3 and meshes with a gear 6 fixed upon a shaft 7 which constitutes the drive shaft for the sound recording mechanism. As before stated, Fig. 2 is merely a diagrammatic representation of the sound and picture recording apparatuses and it will be understood that the gears 5 and 6 may be proportioned otherwise than as shown in the said figure. In other words, the gear 5 may be considerably larger than the gear 6 or the two gears may be proportioned as shown in the said figure, depending upon the construction of the two recording mechanisms and the relative rates of speed at which they are to be driven in order that the picture and sound records may be properly recorded and in synchronism. Thus it may be found expedient to feed the sound recording film at a higher rate of speed than the picture recording film or vice versa. As before stated, there are numerous methods whereby the sounds may be recorded and therefore no particular mechanism is shown in the drawings. It will be understood, however, that the final record produced is to possess the same characteristics as the picture record. In other words, if the picture record is in the nature of a film the sound record will also be in the nature of a film or strip bearing a photographic record of the sounds to be reproduced.

The sound reproducing apparatus embodying the present invention is mounted within a suitable casing indicated in general by the numeral 8, which casing is arranged beside the motion picture projection apparatus which is of the ordinary construction and includes a film feed sprocket 9 driven from a pinion 10, which pinion is in turn driven by a train of gearing set in motion

take-up reel 13. Mounted between the reels upon shafts 14 and 15, respectively, are film sprockets 16 and 17, these shafts respectively carrying also pinions 18 and 19 both of which mesh with a gear 20 fixed upon a shaft 21. Idle rolls 22 and 23 coact respectively with the film sprockets 16 and 17 and the film bearing the sound record is trained to pass between the said sprockets 16 and 17 and their respective idle rolls and is fed from the storage reel 12 to the take-up reel 13 through rotation of the sprocket. Such rotation may be accomplished by extending the shaft 15 to and connecting the same with the shaft for the pinion 10 or the shaft for the pinion 10 may be coupled in any suitable manner with the shaft 21. If desired, furthermore, any suitable gear connection may be provided between the film sprocket 9 or its pinion 10 and a rotary element of the sound producing apparatus. In any event the arrangement will be such that when the crank handle 11 is turned to feed the motion picture film, the sound reproducing mechanism will be actuated to so feed the sound record film that the sound and picture records will be reproduced in perfect syncronism. By providing gear connection between the two pinions 18 and 19, the film sprockets 16 and 17 are caused to rotate in unison and the stretch of film passing between these sprockets will maintain a flat and taut position and will not sag or buckle. The said stretch of film passes over a casing 24 from which light is excluded except for such rays as may pass through a narrow slit 25 or passage-way provided in the top of the casing. Located below this slit, which slit corresponds in dimensions to the slit through which the light rays from the manometric flame pass in producing the sound record, is a selenium cell 26. The said selenium cell is located wholly within the light-tight casing and connected by an electric circuit 27 with a battery 28 and a loud speaking telephone 29, the horn of which, indicated by the numeral 30, is preferably positioned immediately in the rear of the screen 31 upon which the motion pictures are to be projected. An arc or other suitable light 32 is positioned so that its rays will fall upon the top of the casing 24, into which they may pass only through the slit 25. If desired a lens 33 or a cell 33′, or both, containing a solution of alum or iodin may be interposed between the arc light 32 and the slit 25. It will now be understood that as the film bearing the sound record passes the slit 25, the light rays will be permitted to pass through the film and through the said slit with varying intensity, desired either of the film sprockets 15 or 16 may be provided with some indicating mark to indicate to the operator the point to which the film is to be fed through the mechanism in order to position the advancing end of the film so that when the two mechanisms are actuated in unison, the first sounds reproduced will bear proper relation to the action being depicted upon the screen 31. If the element 33 is in the nature of a lens it may, of course, be adjusted to focus the light rays upon the slit 25 or if the light 32 is of such character as to give off great heat the element 33 will be in the nature of a cell containing an alum or iodin solution.

If instead of employing a more or less transparent film for the sound record, the said record is photographically printed upon a strip or film which is opaque and provided with a sensitized coating, the said strip or film and the source of light will be so placed that the light will be reflected from the surface of film or strip and through the slit 25 onto the selenium cell.

Should the scenes to be photographed to produce the picture record be enacted under such conditions that it would be impractical to obtain the desired sound record, the action may be photographed first and the picture record produced may then be projected on to the screen and at the proper moments the actors who enacted the scene or act may speak or produce the proper and related sounds directly into the transmitter of the sound recording apparatus.

It will be understood that any other substance or device, the electrical resistance of which is varied by variations in the intensity of light rays striking it, may be employed in lieu of the selenium cells. Also instead of employing the ordinary induction coil in the telephone circuit I may employ a sound amplifying device which is more sensitive than such a coil.

Having thus described the invention, what is claimed as new is:

In a sound reproducing apparatus, an outer casing, spaced film sprockets mounted therein and having sprocket shafts, pinions on said shafts, a light-tight inner casing mounted within the outer casing between said sprockets and provided in the top wall thereof with a slit, a gear common to both of said pinions coupling the sprockets to turn in unison for feeding a film across the top wall of the inner casing over said slit and maintaining the stretch of film between the sprockets taut, a selenium cell housed within the inner casing, a sound reproducing device and source of electrical energy in circuit with said cell, and a source of light

by sounds striking the same. In this manner, of course, a record will be produced corresponding to the negative record produced upon the photographic film and a print may be made therefrom upon a sensitized film in the same manner as above explained. In fact, a record could be made by employing a vibratory impression element supplied with ink or other substance designed to apply a coating, to a transparent film, of a greater or less width according to the degree of vibration and prints could be made photographically from a record thus produced, upon a photographically sensitized film. Another method which may be followed, consists in providing a telephone receiver with a mirrored diaphragm which is presented toward the slit and over the film. A steady light is thrown on to the mirrored diaphragm and the sounds, collected by a telephone transmitter in circuit with the said receiver, will cause the mirrored diaphragm of the said receiver to vibrate thereby causing variations in the intensity of the light rays reflected on to the film. The methods above briefly described employ a strip or film as will be noted. However, inasmuch as it has been proposed to take and project motion pictures through the employment of a revolving glass disk upon which the picture records are photographically impressed, the present invention contemplates the employment, in such event, of a similar sound record. Assuming that the sound record is produced by photographically impressing the record upon a sensitized film such as employed in a motion picture camera, the film feeding mechanism for the camera and the film feeding mechanism for the sound recording apparatus are more or less directly connected for operation in unison and in preparing the two mechanisms for use their respective films are threaded therein and operation of the camera mechanism will result in operation of the sound recording mechanism in synchronism therewith. Thus the sounds are recorded in exact synchronism with the related scenes or acts and positive films prepared from the two negative film records thus produced may be employed in a similar arrangement of a projection apparatus and sound reproducing apparatus to cause reproduction of the two records in synchronism.

The invention also, as before stated, contemplates the provision of an apparatus for reproducing the picture and sound records in synchronism.

In the accompanying drawings:

Figure 1 is a view illustrating diagrammatically the apparatus for and method of reproducing the sound and picture records;

Fig. 2 is a view illustrating diagrammatically the sound recording mechanism coupled for simultaneous operation;

Fig. 3 is a perspective view of a motion picture projecting machine and the sound reproducing apparatus embodying the invention;

Fig. 4 is a view in side elevation of the apparatus removed from its casing.

In Fig. 2 of the drawings there is illustrated diagrammatically a motion picture camera indicated by the numeral 1 and there is also shown in the said figure the casing for the sound recording apparatus, indicated in general by the numeral 2. The numeral 3 indicates a shaft which is connected with and driven from any suitable rotary element of the camera mechanism and which at its outer end seats in a bearing 4 upon a side of the casing 2 for the sound recording mechanism. A gear or pinion 5 is fixed upon the shaft 3 and meshes with a gear 6 fixed upon a shaft 7 which constitutes the drive shaft for the sound recording mechanism. As before stated, Fig. 2 is merely a diagrammatic representation of the sound and picture recording apparatuses and it will be understood that the gears 5 and 6 may be proportioned otherwise than as shown in the said figure. In other words, the gear 5 may be considerably larger than the gear 6 or the two gears may be proportioned as shown in the said figure, depending upon the construction of the two recording mechanisms and the relative rates of speed at which they are to be driven in order that the picture and sound records may be properly recorded and in synchronism. Thus it may be found expedient to feed the sound recording film at a higher rate of speed than the picture recording film or vice versa. As before stated, there are numerous methods whereby the sounds may be recorded and therefore no particular mechanism is shown in the drawings. It will be understood, however, that the final record produced is to possess the same characteristics as the picture record. In other words, if the picture record is in the nature of a film the sound record will also be in the nature of a film or strip bearing a photographic record of the sounds to be reproduced.

The sound reproducing apparatus embodying the present invention is mounted within a suitable casing indicated in general by the numeral 8, which casing is arranged beside the motion picture projection apparatus which is of the ordinary construction and includes a film feed sprocket 9 driven from a pinion 10, which pinion is in turn driven by a train of gearing set in motion by power such as the usual crank handle 11. The said sound reproducing apparatus includes a storage reel 12 for the film and a

take-up reel 13. Mounted between the reels upon shafts 14 and 15, respectively, are film sprockets 16 and 17, these shafts respectively carrying also pinions 18 and 19 both of which mesh with a gear 20 fixed upon a shaft 21. Idle rolls 22 and 23 coact respectively with the film sprockets 16 and 17 and the film bearing the sound record is trained to pass between the said sprockets 16 and 17 and their respective idle rolls and is fed from the storage reel 12 to the take-up reel 13 through rotation of the sprocket. Such rotation may be accomplished by extending the shaft 15 to and connecting the same with the shaft for the pinion 10 or the shaft for the pinion 10 may be coupled in any suitable manner with the shaft 21. If desired, furthermore, any suitable gear connection may be provided between the film sprocket 9 or its pinion 10 and a rotary element of the sound producing apparatus. In any event the arrangement will be such that when the crank handle 11 is turned to feed the motion picture film, the sound reproducing mechanism will be actuated to so feed the sound record film that the sound and picture records will be reproduced in perfect syncronism. By providing gear connection between the two pinions 18 and 19, the film sprockets 16 and 17 are caused to rotate in unison and the stretch of film passing between these sprockets will maintain a flat and taut position and will not sag or buckle. The said stretch of film passes over a casing 24 from which light is excluded except for such rays as may pass through a narrow slit 25 or passage-way provided in the top of the casing. Located below this slit, which slit corresponds in dimensions to the slit through which the light rays from the manometric flame pass in producing the sound record, is a selenium cell 26. The said selenium cell is located wholly within the light-tight casing and connected by an electric circuit 27 with a battery 28 and a loud speaking telephone 29, the horn of which, indicated by the numeral 30, is preferably positioned immediately in the rear of the screen 31 upon which the motion pictures are to be projected. An arc or other suitable light 32 is positioned so that its rays will fall upon the top of the casing 24, into which they may pass only through the slit 25. If desired a lens 33 or a cell 33′, or both, containing a solution of alum or iodin may be interposed between the arc light 32 and the slit 25. It will now be understood that as the film bearing the sound record passes the slit 25, the light rays will be permitted to pass through the film and through the said slit with varying intensity, and acting upon the selenium cell 26 to vary the resistance thereof, the corresponding vibrations will be set up in the loud speaking telephone thus reproducing the sound. If desired either of the film sprockets 16 or 17 may be provided with some indicating mark to indicate to the operator the point to which the film is to be fed through the mechanism in order to position the advancing end of the film so that when the two mechanisms are actuated in unison, the first sounds reproduced will bear proper relation to the action being depicted upon the screen 31. If the element 33 is in the nature of a lens it may, of course, be adjusted to focus the light rays upon the slit 25 or if the light 32 is of such character as to give off great heat the element 33 will be in the nature of a cell containing an alum or iodin solution.

If instead of employing a more or less transparent film for the sound record, the said record is photographically printed upon a strip or film which is opaque and provided with a sensitized coating, the said strip or film and the source of light will be so placed that the light will be reflected from the surface of film or strip and through the slit 25 onto the selenium cell.

Should the scenes to be photographed to produce the picture record be enacted under such conditions that it would be impractical to obtain the desired sound record, the action may be photographed first and the picture record produced may then be projected on to the screen and at the proper moments the actors who enacted the scene or act may speak or produce the proper and related sounds directly into the transmitter of the sound recording apparatus.

It will be understood that any other substance or device, the electrical resistance of which is varied by variations in the intensity of light rays striking it, may be employed in lieu of the selenium cells. Also instead of employing the ordinary induction coil in the telephone circuit I may employ a sound amplifying device which is more sensitive than such a coil.

Having thus described the invention, what is claimed as new is:

In a sound reproducing apparatus, an outer casing, spaced film sprockets mounted therein and having sprocket shafts, pinions on said shafts, a light-tight inner casing mounted within the outer casing between said sprockets and provided in the top wall thereof with a slit, a gear common to both of said pinions coupling the sprockets to turn in unison for feeding a film across the top wall of the inner casing over said slit and maintaining the stretch of film between the sprockets taut, a selenium cell housed within the inner casing, a sound reproducing device and source of electrical energy in circuit with said cell, and a source of light for projecting light rays through the film and said slit upon said cell.

In testimony whereof I affix my signature.

LEE A. COLLINS. [L. S.]

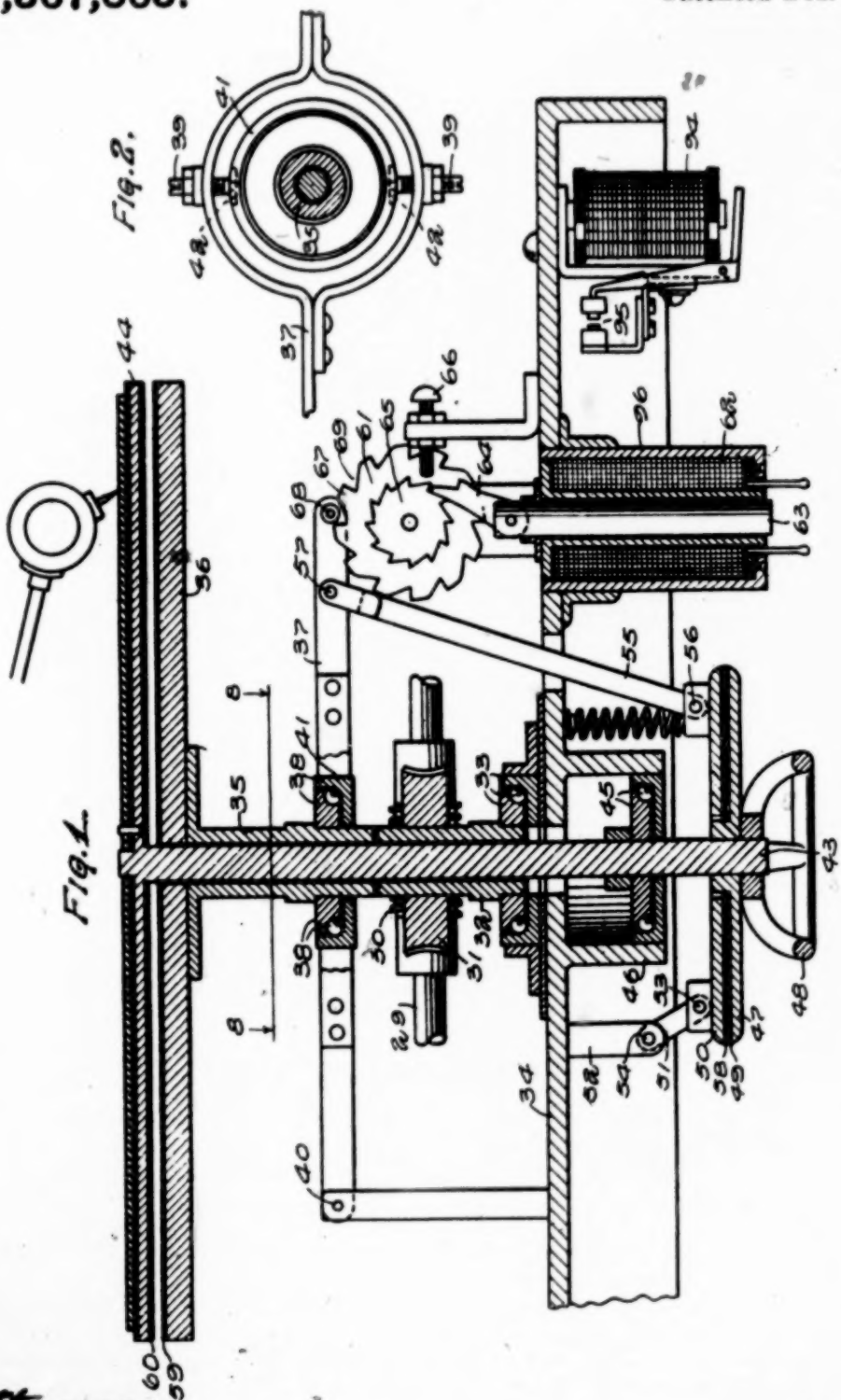
1156

W. M. CLARK.

TALKING MACHINE FOR MOVING PICTURE APPARATUS.

APPLICATION FILED JULY 12, 1915.

1,367,863. Patented Feb. 8, 1921.



Witnesses:

INVENTOR:

W. M. Clark

UNITED STATES PATENT OFFICE.

WILLIAM M. CLARK, OF CHICAGO, ILLINOIS.

TALKING-MACHINE FOR MOVING-PICTURE APPARATUS.

1,367,863. Specification of Letters Patent. Patented Feb. 8, 1921.

Application filed July 12, 1915. Serial No. 39,335.

To all whom it may concern:

Be it known that I, WILLIAM M. CLARK, a citizen of the United States of America, and resident of Chicago, Cook county, Illinois, have invented a certain new and useful Improvement in Talking-Machines for Moving-Picture Apparatus, of which the following is a specification.

My invention relates to an improved form of phonographic apparatus which is specially applicable for use in connection with moving picture apparatus. Heretofore there has been a great deal of difficulty in working phonographic apparatus satisfactorily in synchronism with a moving picture projector, and I have a device and new means for running the two in a satisfactory and reliable manner.

Among the objects of my invention are the provision of means for connecting the projector shaft and the driving shaft of the phonographic apparatus; the provision of improved means for controlling the phonographic records, and the provision of certain details and feautres of improvement tending to increase the efficiency and serviceability of apparatus of the above character.

To accomplish the foregoing and other useful ends I provide means hereinafter more fully set forth and claimed.

Figure 1 shows in detail the driving and controlling mechanism in the phonograph apparatus.

Fig. 2 is a detail with parts shown in section of one of the bearings in Fig. 1 showing how it is pivoted.

Referring to Fig. 1, the shaft 29 is the driving shaft and carries a worm gear 30. This worm gear engages the gear wheel 31, which is rigidly secured to the hollow shaft 32. This shaft 32 is sustained by the bearing 33, which is in turn secured to a main frame 34. The hollow shaft 35 to which is permanently secured the fly wheel 36 is locked in driving engagement with the shaft 32, but nevertheless this shaft 35 may be raised and lowered, while in driving engagement with the shaft 32, through the

of the lever 37 about the pivot 40 to which the shaft 37 is secured, will not operate to throw the shaft 35 out of alinement. The trunnions 39 engage the housing 41 of the bearings 38 in horizontal slots 42, so as to permit the trunnions 39 to move from left to right and from right to left, as the lever 37 rises and falls. Within the hollow shafts 32 and 35 there is a shaft 43, to the upper end of which there is attached the disk supporting plate 44. This shaft and disk are made of light material, so as to insure a low inertia, in order that the plate 44 may be started and stopped very quickly. The shaft 43 is provided with bearings 45 in a suitable housing 46, which is built upon the under side of the main frame 34. Near the lower end of the shaft 43 there is provided a disk 47, which is permanently fixed to the shaft. Below this disk there is provided a hand wheel 48 for controlling the shaft 43. On the upper surface of the plate 47 there is provided a leather surface 49. Just above this leather surface there is a plate 50 supported by the link 51 to the post 52, which is a part of the frame 34. This link 51 is pivoted at the points 53 and 54. The plate 50 is also sustained by another link 55, which is secured to the lever 37. This link 55 is pivoted at the points 56 and 57. The under side of the plate 50 is also provided with a leather surface 58. The upper side of the fly wheel 36 is provided with a felt surface 59, while the under side of the record holding disk 44 is likewise provided with a felt surface 60. The lever 37 is controlled by a cam wheel 61, which wheel is in turn controlled by the solenoid 62, the core 63 of which carries a pawl 64. It will be seen that when the shaft 29 is rotated, the fly wheel 36 is rotated through the medium of the worm 30, gear wheel 31, and shafts 32 and 35. Now, if the solenoid 62 is energized, the plunger 63 raises the pawl 64, which latter by engaging the tooth wheel 65 rotates the cam wheel 61 until the pawl 64 strikes the bumping post 66. As a result, the tooth 67 on the cam wheel 61 by engaging the pin 68 on the lever 37, raises the

TALKING MACHINE FOR MOVING PICTURE APPARATUS.

APPLICATION FILED JULY 12, 1915.

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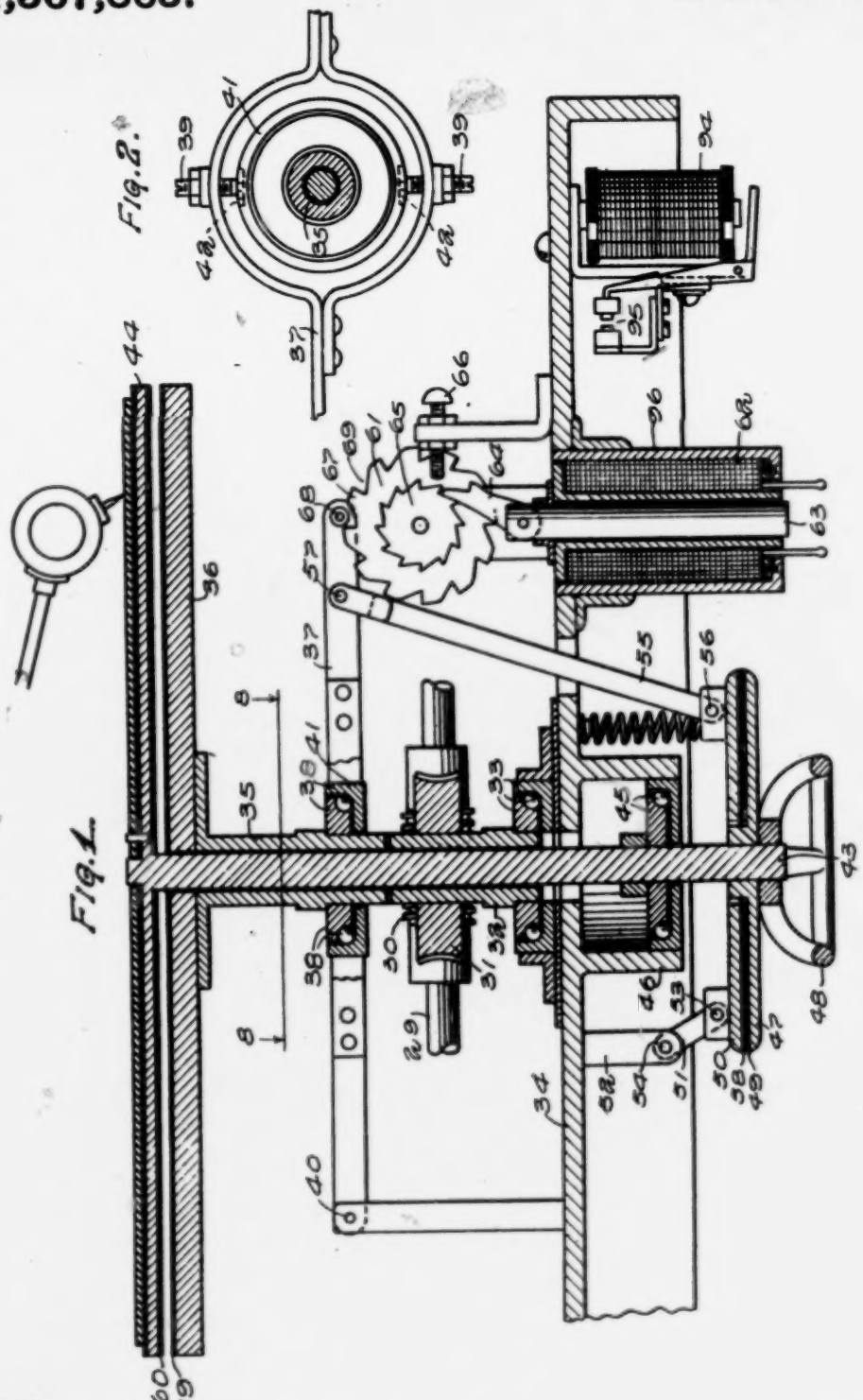

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UNITED STATES PATENT OFFICE.

WILLIAM M. CLARK, OF CHICAGO, ILLINOIS.

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Among the objects of my invention are the provision of means for connecting the projector shaft and the driving shaft of the phonographic apparatus; the provision of improved means for controlling the phonographic records, and the provision of certain details and feautres of improvement tending to increase the efficiency and serviceability of apparatus of the above character.

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Referring to Fig. 1, the shaft 29 is the driving shaft and carries a worm gear 30. This worm gear engages the gear wheel 31, which is rigidly secured to the hollow shaft 32. This shaft 32 is sustained by the bearing 33, which is in turn secured to a main frame 34. The hollow shaft 35 to which is permanently secured the fly wheel 36 is locked in driving engagement with the shaft 32, but nevertheless this shaft 35 may be raised and lowered, while in driving engagement with the shaft 32, through the medium of the lever 37. Upon this lever 37 is pivotally mounted the bearings 38, which sustain the shaft 35. These bearings, as shown in Fig. 2, are supported by the trunnions 39, so that the rotary movement of the lever 37 about the pivot 40 to which the shaft 37 is secured, will not operate to throw the shaft 35 out of alinement. The trunnions 39 engage the housing 41 of the bearings 38 in horizontal slots 42, so as to permit the trunnions 39 to move from left to right and from right to left, as the lever 37 rises and falls. Within the hollow shafts 32 and 35 there is a shaft 43, to the upper end of which there is attached the disk supporting plate 44. This shaft and disk are made of light material, so as to insure a low inertia, in order that the plate 44 may be started and stopped very quickly. The shaft 43 is provided with bearings 45 in a suitable housing 46, which is built upon the under side of the main frame 34. Near the lower end of the shaft 43 there is provided a disk 47, which is permanently fixed to the shaft. Below this disk there is provided a hand wheel 48 for controlling the shaft 43. On the upper surface of the plate 47 there is provided a leather surface 49. Just above this leather surface there is a plate 50 supported by the link 51 to the post 52, which is a part of the frame 34. This link 51 is pivoted at the points 53 and 54. The plate 50 is also sustained by another link 55, which is secured to the lever 37. This link 55 is pivoted at the points 56 and 57. The under side of the plate 50 is also provided with a leather surface 58. The upper side of the fly wheel 36 is provided with a felt surface 59, while the under side of the record holding disk 44 is likewise provided with a felt surface 60. The lever 37 is controlled by a cam wheel 61, which wheel is in turn controlled by the solenoid 62, the core 63 of which carries a pawl 64. It will be seen that when the shaft 29 is rotated, the fly wheel 36 is rotated through the medium of the worm 30, gear wheel 31, and shafts 32 and 35. Now, if the solenoid 62 is energized, the plunger 63 raises the pawl 64, which latter by engaging the tooth wheel 65 rotates the cam wheel 61 until the pawl 64 strikes the bumping post 66. As a result, the tooth 67 on the cam wheel 61 by engaging the pin 68 on the lever 37, raises the lever, the pin 68 resting for the time being on the top of the tooth 67, even though the magnet 62 deënergizes and the plunger 63 be withdrawn. As a result of raising the lever 37, the fly wheel 36 is raised into en-

gagement with the disk 44, whereupon the disk 44 immediately starts rotating with the fly wheel 36 and at the same speed. This occurs with practically no slipping between the surfaces 59 and 60, and therefore the disk 44 attains its maximum speed almost instantly, and in fact, instantly for all practical purposes. This rotation of the disk 44 continues until the magnet 62 is energized again, whereupon the pawl 64 advances the cam wheel 61 another step, with the result that the pin 68 on the arm 37 falls in the notch 69. When this occurs the fly wheel 36 disengages from the plate 44, and at the same time the plate 50 at the other end of the shaft is carried into engagement with the shaft disk 47, thereby bringing the disk 44 instantly to a standstill.

It may be here pointed out that this invention is particularly useful in connection with a talking picture and that the apparatus shown may be readily controlled by electrical circuits controlled by switches on the film of the motion picture apparatus and that any number of talking machines may be used and controlled by switches on a single film; the solenoid 62 being controlled by the circuit closing magnet 94 which would in practice be controlled by a film or in any other desired manner. In this way it would be possible to make relay 94 sensitive and yet close a high power circuit for the solenoid.

It should be explained that the hand wheel 48 at the bottom of the shaft 43 (Fig. 1) is for the purpose of throwing the apparatus into synchronism, in the event that it has been thrown out of synchronism as a result of the film having broken. For example, as soon as the film breaks, the circuit through the springs 27 is broken, as already explained, with the result that the instrument comes to a standstill. However, it is possible that the machine will continue to operate for a sufficient length of time to permit two or three of the pictures to pass through the fire roller after the break. That being the case, the film will be out of synchronism with the phonograph, which comes to a standstill immediately. The plate 44 is divided off into sections, each corresponding to a picture on the film so that if the phonograph is three pictures out of synchronism with the rest of the apparatus, which of course, includes the plate 36, it may be thrown back into synchronism by merely turning the wheel 48 until the plate 44 has been advanced a space equivalent to three pictures. This method of throwing the phonographic rec- with the phonograph. The attendant then may by quickly touching the wheel 48, while it is rotating, advance or retard the disk 44 sufficiently to throw the apparatus back into proper adjustment.

My invention also includes the provision of hand controlled means including the hand wheel 48 (Fig. 1) for the purpose of advancing or retarding the phonograph record in the event that it has gotten out of synchronism with the film, which synchronizing arrangement may be carried on while the film and phonograph equipment are running. It will be seen, therefore, that my invention includes an automatic arrangement employing the slotted film and the trip circuit controlling device having the wheels 11 and 12 through the medium of which one phonograph is brought into use at a time one after another, or several phonographs may be brought in together, and through the medium of which automatic arrangement the stopping of any one or all of the phonographs is under the automatic control of the film.

My invention also contemplates the use of this automatic arrangement for starting and stopping any one or any number of the phonographs by the film not only after the reproducer has reached the end of the record, but any number of times before it reaches the end of the record.

It also includes an automatic stop arrangement under the control of the film for stopping the projector and the phonograph or phonographs in the event that the film breaks or is burned in two, which arrangement includes the circuit controlling roller 25 associated with the aperture plate.

The invention also includes an arrangement including a spring drive interposed between a moving picture or projector and a phonograph drive to prevent the vibrations from the projector affecting the phonograph apparatus. This arrangement includes the pins and coil spring band between the faces of the drive.

My invention also includes the provision of hand-controlled means including the hand wheel 48 (Fig. 1) for the purpose of advancing or retarding the phonograph record, in the event that it has gotten out of synchronism with the film, which syncronizing arrangement may be carried on while the film and phonograph equipment are running.

What I claim as my invention is:

1. In a phonograph machine, a record holder, a driver therefor, means comprising a magnetically driven ratchet for mov-

holder for driving the holder, a brake for said holder, and means for disengaging said driver from said plate and for applying said brake to the holder.

3. In a phonograph machine, a record holder, a driver therefor, means for moving said driver into engagement with said holder for driving the holder, a brake for said holder, an electromagnetic means for disengaging said driver from said holder and for applying said brake to the holder.

4. In a phonograph machine, a record holder, a driver therefor, a controlling device for moving said driver into engagement with said holder for driving the holder, a brake for said holder, said controlling device also for disengaging said driver from the holder and for applying the brake to the holder, and a magnet for operating said controlling device.

5. In a phonograph machine, a record holder, a driver therefor, means for moving said driver into engagement with said holder for driving the holder, a brake for said holder, said means also for disengaging said driver from said holder and for applying said brake to the holder, said means comprising a magnet and a controlling device operated thereby.

6. In a phonograph machine, a record holder, a driver therefor, means for moving said driver into engagement with said holder for driving the holder, a brake for the holder, said means also for disengaging said driver from said holder, and for applying said brake to the holder, said means consisting of a magnet and a step by step controlling device operated thereby.

7. In a phonograph machine, a record holder, a driver therefor, a brake for said holder, a magnetically driven ratchet, and an arm controlled by said ratchet for moving said driver into and out of engagement with said holder to drive the same and for applying the brake to the holder at the same time that the driver is disengaged from the holder.

Signed by me at Chicago, Illinois, this 26th day of June, 1915.

W. M. CLARK.

Witnesses:
CHAS. M. CAUDY,
B. GARBER.

disk 44 immediately starts rotating with the fly wheel 36 and at the same speed. This occurs with practically no slipping between the surfaces 59 and 60, and therefore the disk 44 attains its maximum speed almost instantly, and in fact, instantly for all practical purposes. This rotation of the disk 44 continues until the magnet 62 is energized again, whereupon the pawl 64 advances the cam wheel 61 another step, with the result that the pin 68 on the arm 37 falls in the notch 69. When this occurs the fly wheel 36 disengages from the plate 44, and at the same time the plate 50 at the other end of the shaft is carried into engagement with the shaft disk 47, thereby bringing the disk 44 instantly to a standstill.

It may be here pointed out that this invention is particularly useful in connection with a talking picture and that the apparatus shown may be readily controlled by electrical circuits controlled by switches on the film of the motion picture apparatus and that any number of talking machines may be used and controlled by switches on a single film; the solenoid 62 being controlled by the circuit closing magnet 94 which would in practice be controlled by a film or in any other desired manner. In this way it would be possible to make relay 94 sensitive and yet close a high power circuit for the solenoid.

It should be explained that the hand wheel 48 at the bottom of the shaft 43 (Fig. 1) is for the purpose of throwing the apparatus into synchronism, in the event that it has been thrown out of synchronism as a result of the film having broken. For example, as soon as the film breaks, the circuit through the springs 27 is broken, as already explained, with the result that the instrument comes to a standstill. However, it is possible that the machine will continue to operate for a sufficient length of time to permit two or three of the pictures to pass through the fire roller after the break. That being the case, the film will be out of synchronism with the phonograph, which comes to a standstill immediately. The plate 44 is divided off into sections, each corresponding to a picture on the film so that if the phonograph is three pictures out of synchronism with the rest of the apparatus, which of course, includes the plate 36, it may be thrown back into synchronism by merely turning the wheel 48 until the plate 44 has been advanced a space equivalent to three pictures. This method of throwing the phonographic record into synchronism with the rest of the apparatus may be utilized even while the equipment is running. Sometimes it happens that the film is imperfect, and for that reason begins to run out of synchronism may by quickly touching the wheel 48, while it is rotating, advance or retard the disk 44 sufficiently to throw the apparatus back into proper adjustment.

My invention also includes the provision of hand controlled means including the hand wheel 48 (Fig. 1) for the purpose of advancing or retarding the phonograph record in the event that it has gotten out of synchronism with the film, which synchronizing arrangement may be carried on while the film and phonograph equipment are running. It will be seen, therefore, that my invention includes an automatic arrangement employing the slotted film and the trip circuit controlling device having the wheels 11 and 12 through the medium of which one phonograph is brought into use at a time one after another, or several phonographs may be brought in together, and through the medium of which automatic arrangement the stopping of any one or all of the phonographs is under the automatic control of the film.

My invention also contemplates the use of this automatic arrangement for starting and stopping any one or any number of the phonographs by the film not only after the reproducer has reached the end of the record, but any number of times before it reaches the end of the record.

It also includes an automatic stop arrangement under the control of the film for stopping the projector and the phonograph or phonographs in the event that the film breaks or is burned in two, which arrangement includes the circuit controlling roller 25 associated with the aperture plate.

The invention also includes an arrangement including a spring drive interposed between a moving picture or projector and a phonograph drive to prevent the vibrations from the projector affecting the phonograph apparatus. This arrangement includes the pins and coil spring band between the faces of the drive.

My invention also includes the provision of hand-controlled means including the hand wheel 48 (Fig. 1) for the purpose of advancing or retarding the phonograph record, in the event that it has gotten out of synchronism with the film, which syncronizing arrangement may be carried on while the film and phonograph equipment are running.

What I claim as my invention is:

1. In a phonograph machine, a record holder, a driver therefor, means comprising a magnetically driven ratchet for moving said driver into engagement with said holder for driving the holder.

2. In a phonograph machine, a record holder, a driver therefor, means for moving said driver into engagement with said

said holder, and means for disengaging said driver from said plate and for applying said brake to the holder.

3. In a phonograph machine, a record holder, a driver therefor, means for moving said driver into engagement with said holder for driving the holder, a brake for said holder, an electromagnetic means for disengaging said driver from said holder and for applying said brake to the holder.

4. In a phonograph machine, a record holder, a driver therefor, a controlling device for moving said driver into engagement with said holder for driving the holder, a brake for said holder, said controlling device also for disengaging said driver from the holder and for applying the brake to the holder, and a magnet for operating said controlling device.

5. In a phonograph machine, a record holder, a driver therefor, means for moving said driver into engagement with said holder for driving the holder, a brake for said holder, said means also for disengaging said driver from said holder and for applying said brake to the holder, said ling device operated thereby.

6. In a phonograph machine, a record holder, a driver therefor, means for moving said driver into engagement with said holder for driving the holder, a brake for the holder, said means also for disengaging said driver from said holder, and for applying said brake to the holder, said means consisting of a magnet and a step by step controlling device operated thereby.

7. In a phonograph machine, a record holder, a driver therefor, a brake for said holder, a magnetically driven ratchet, and an arm controlled by said ratchet for moving said driver into and out of engagement with said holder to drive the same and for applying the brake to the holder at the same time that the driver is disengaged from the holder.

Signed by me at Chicago, Illinois, this 26th day of June, 1915.

W. M. CLARK.

Witnesses:
CHAS. M. CAUDY,
B. GARBER.

1162

J. KUNZ.

PHOTO ELECTRIC CELL, METHOD OF AND MEANS FOR MAKING THE SAME.

APPLICATION FILED AUG. 24, 1918.

1,381,474.

Patented June 14, 1921.

3 SHEETS—SHEET 1.

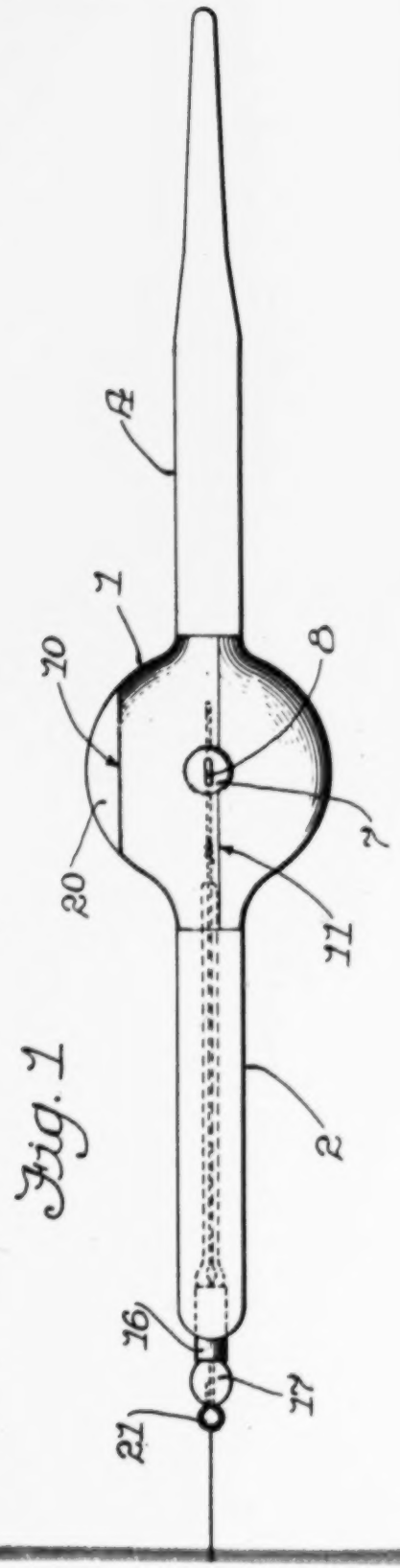

Fig. 1

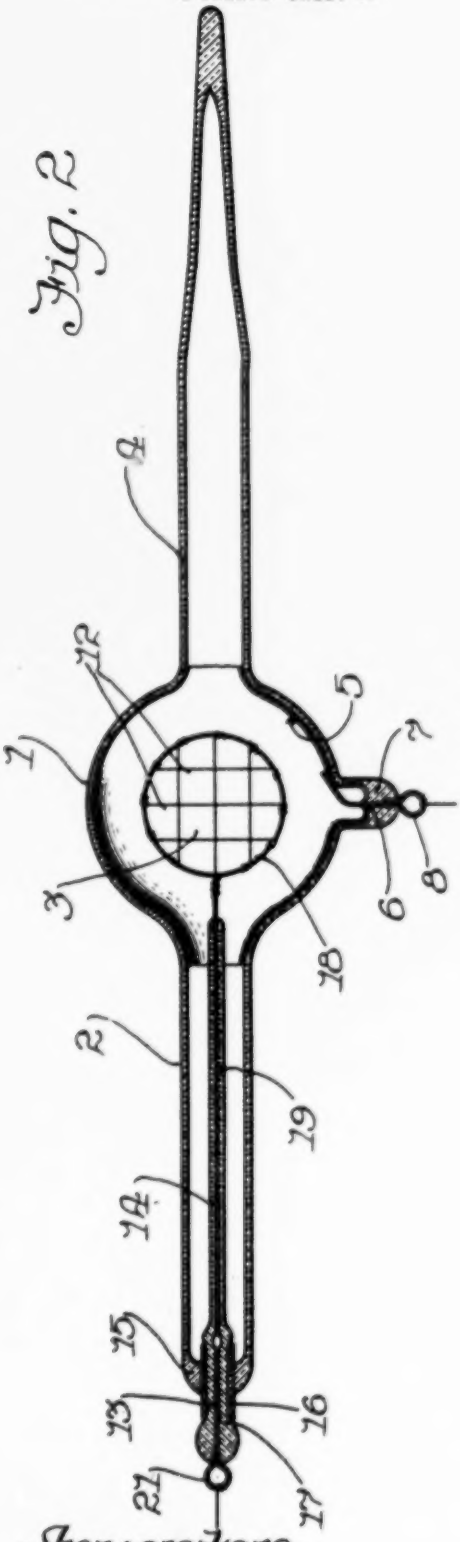

Fig. 2

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PHOTO ELECTRIC CELL, METHOD OF AND MEANS FOR MAKING THE SAME.

APPLICATION FILED AUG. 24, 1918.

1,381,474. **Patented June 14, 1921.**

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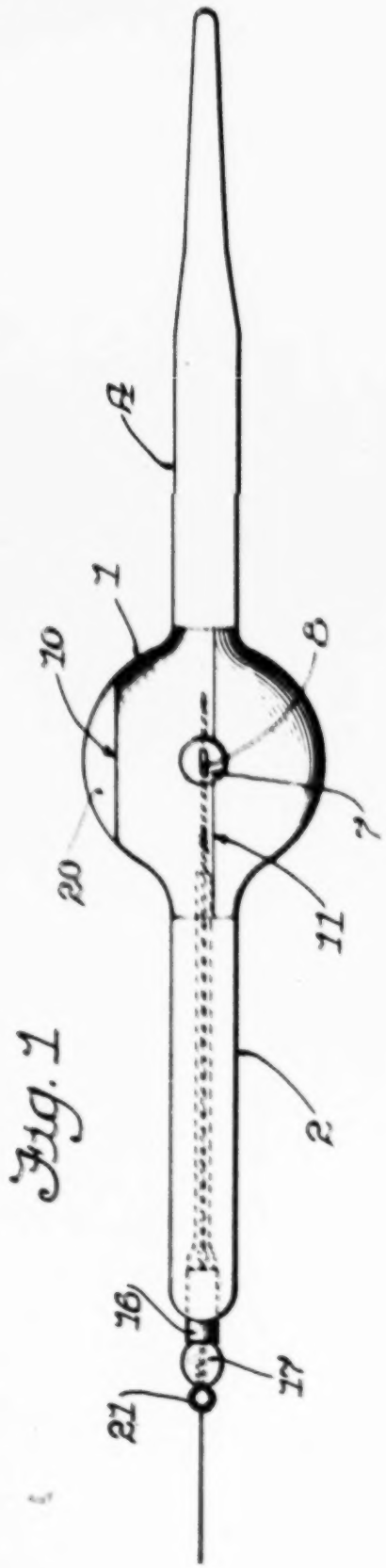

Fig. 1

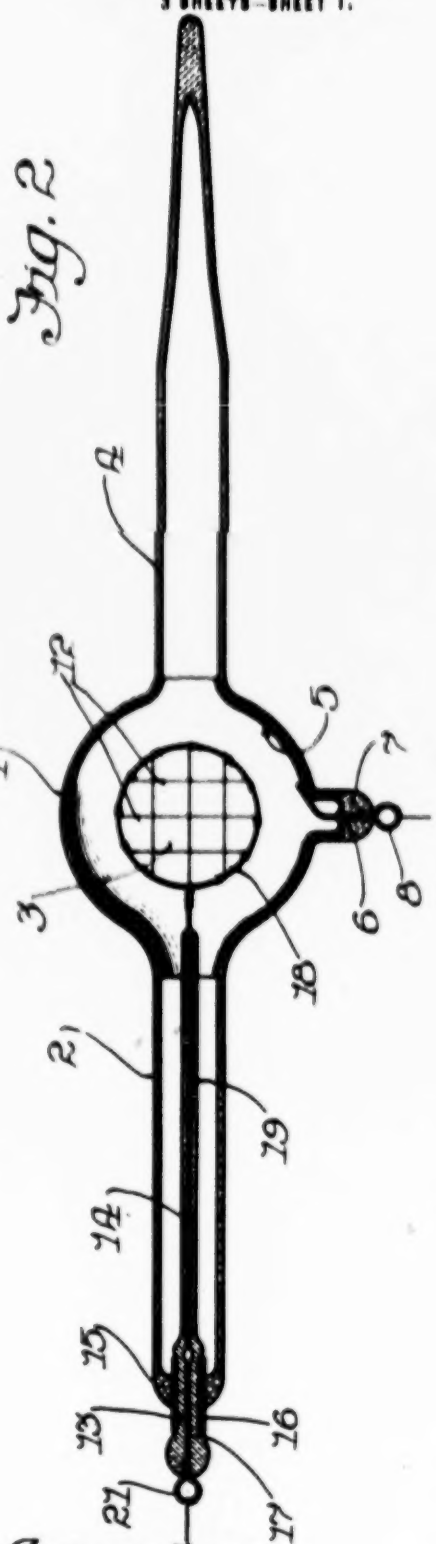

Fig. 2

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PHOTO ELECTRIC CELL, METHOD OF AND MEANS FOR MAKING THE SAME.

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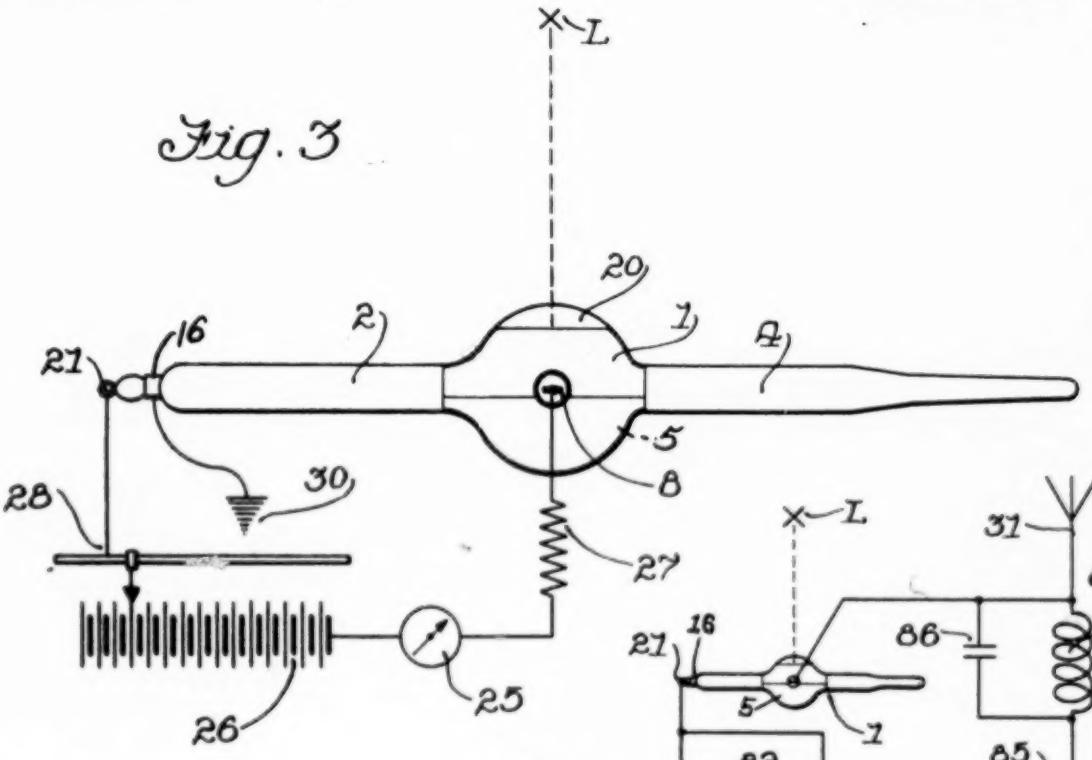
1,381,474.

Patented June 14, 1921.

3 SHEETS—SHEET 2.

Fig. 3



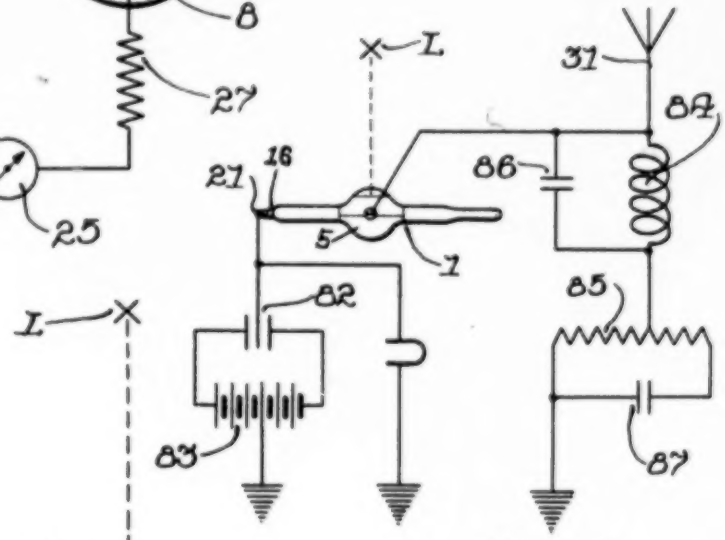


Fig. 6

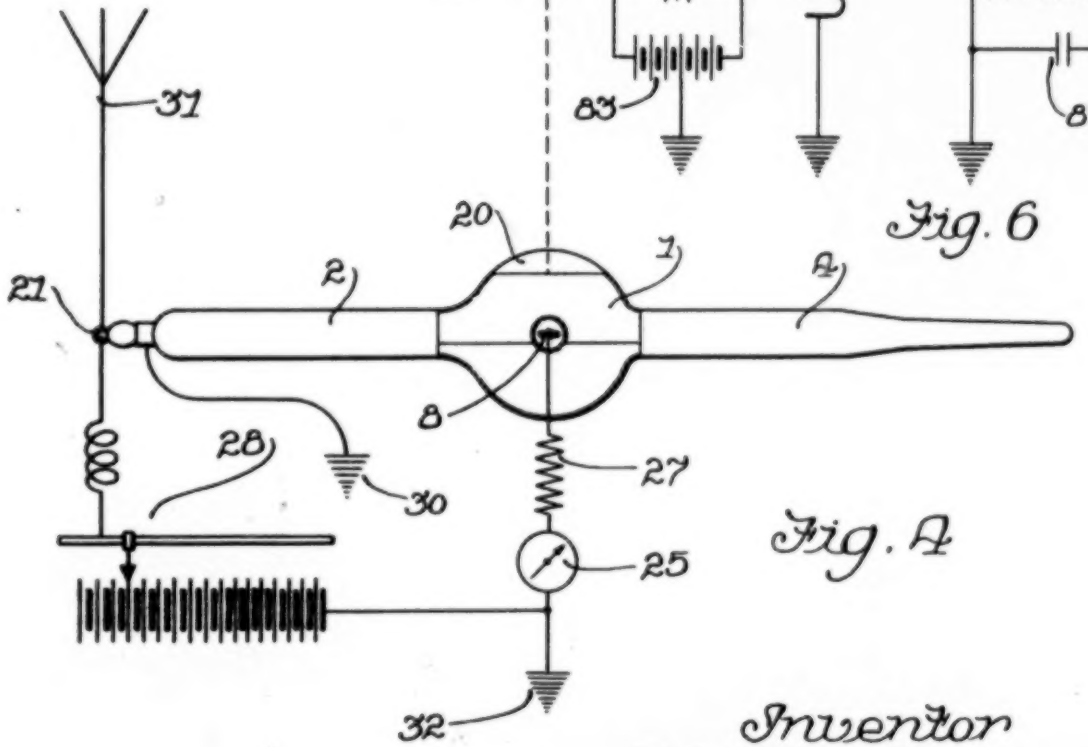


Fig. 4

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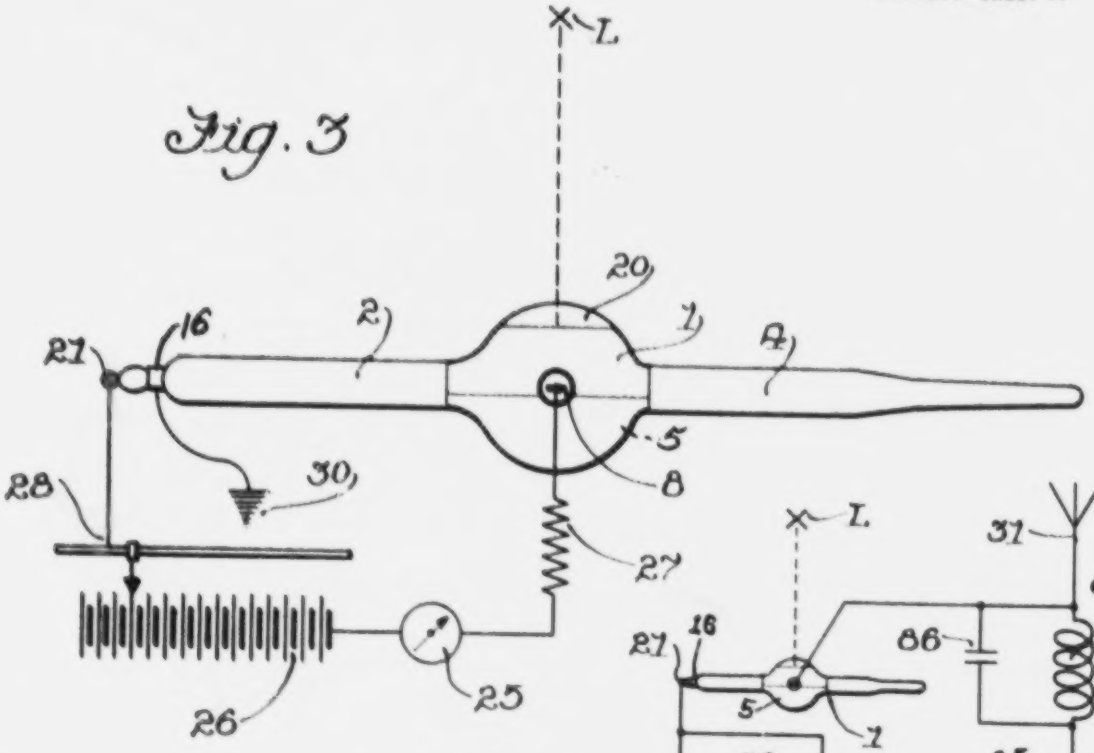
APPLICATION FILED AUG. 24, 1918.

1,381,474. **Patented June 14, 1921.**

3 SHEETS—SHEET 2.

Fig. 3



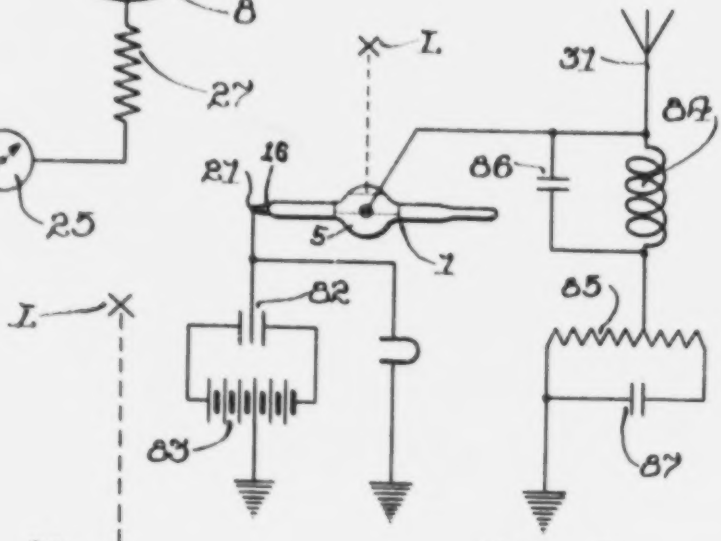


Fig. 6

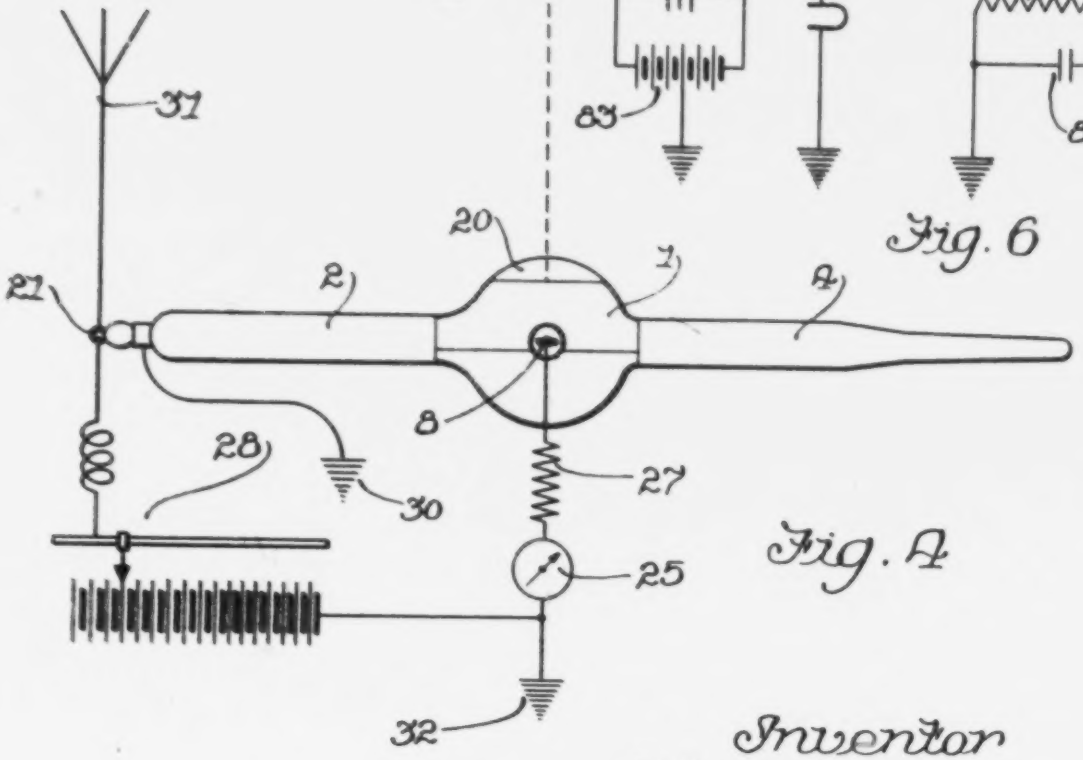


Fig. 4

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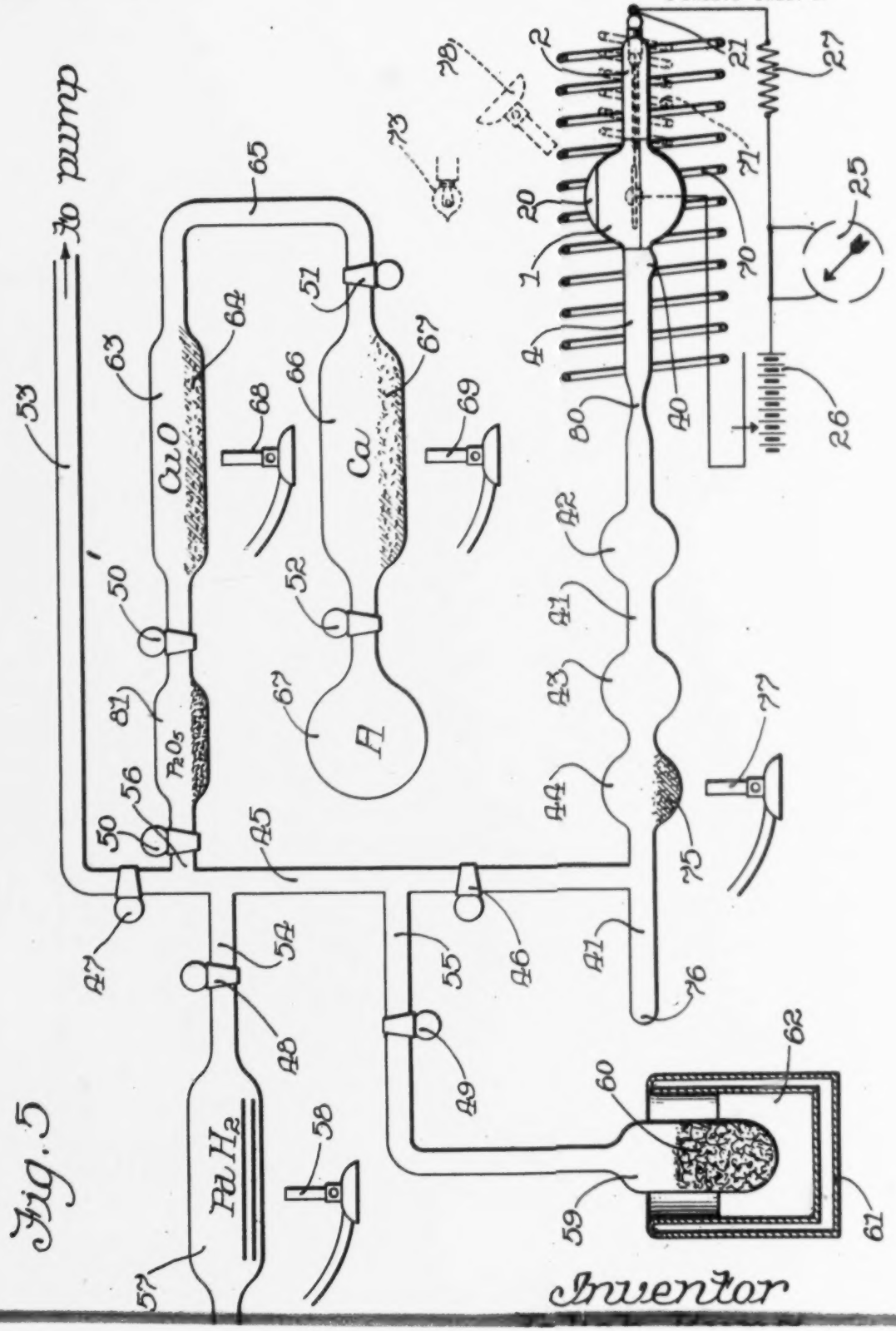

Fig. 5

UNITED STATES PATENT OFFICE.

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PHOTO-ELECTRIC CELL, METHOD OF AND MEANS FOR MAKING THE SAME.

1,381,474. Specification of Letters Patent. Patented June 14, 1921.

Application filed August 24, 1918. Serial No. 251,345.

To all whom it may concern:

Be it known that I, JAKOB KUNZ, a citizen of the United States, residing at Urbana, in the county of Champaign and State of Illinois, have invented a certain new and useful Improvement in Photo-Electric Cells, Methods of and Means for Making the Same, of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawings, forming a part of this specification.

My invention relates to photo-electric cells.

I employ as a sensitive element, a suitable alkali metal. The fact that alkali metals under proper conditions are sensitive to light has previously been known.

There has been an increasing demand in various arts for an accurate and sensitive photo-electric cell. Heretofore selenium has been employed but the selenium cell,—at least as heretofore constructed—has not been sufficiently sensitive, nor are its characteristics suitable for careful work.

My invention aims to provide a cell which shall meet this demand.

I provide an evacuated glass chamber having two electrodes, one of which consists of a dense film of an alkali metal in a suitable form and condition, lying on the inner surface of the chamber. The chamber may be filled with hydrogen or an inert gas, such as nitrogen, argon, helium, or neon or the like. This film electrode is so arranged that the light to be measured will fall upon the same.

The other electrode is placed in the immediate vicinity of the film electrode and is preferably in the form of a screen lying in the path of the entering light, but so constructed as to obstruct the light as little as possible. Between these two electrodes there is formed a field subject to and sensitive to the influence of light.

A cell of this type when properly constructed is characterized by great sensitiveness, uniform sensitiveness over a wide range of light intensities or impressed voltages, not subject to change by aging, rapidity of action, and as I have found by experiment, be employed for measuring light intensity beyond either limit of the range of the human eye. Thus for instance, I have found it possible to measure the light given off by a star of the seventh magnitude or the light from a powerful arc.

The cell of my invention is more sensitive to colors than is the human eye and can be employed for distinguishing objects of different colors such as leaves, glass, silks, etc. It appears that the sensitiveness is greater for short wave lengths, as the cell is more sensitive to blue and ultra violet as well as to Roentgen rays.

I prepare the cell by first depositing a silver mirror in contact with the shorter electrode. Then I connect the cell to a system of pipes and chambers comprising a pump for evacuating the cell and containing in one of the chambers an alkali metal and other chambers various gases required. The metal may be any one of the following group:

Lithium.
Sodium.
Potassium.
Rubidium.
Cæsium.

The cell is carefully evacuated and then the metal is distilled upon the silver mirror and in contact with the short electrode, but is carefully kept off of the other electrode. Thereafter, the cell is filled with hydrogen and is subjected to a relatively high electrical potential to cause a glow discharge of electricity. The tube is then pumped out and thereafter filled with argon, nitrogen, neon or other suitable gas, to the proper degree, and is then sealed off.

In order to explain to those skilled in the art how to construct and practice my invention, I shall now describe one embodiment thereof in connection with the accompanying drawings which form a part of the present specification.

Figure 1 is a side elevation of a cell embodying my invention;

Fig. 2 is a longitudinal axial section taken on a plane at right angles to the plane of

PHOTO ELECTRIC CELL, METHOD OF AND MEANS FOR MAKING THE SAME.

APPLICATION FILED AUG. 24, 1918.

1,381,474.

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3 SHEETS—SHEET 3.

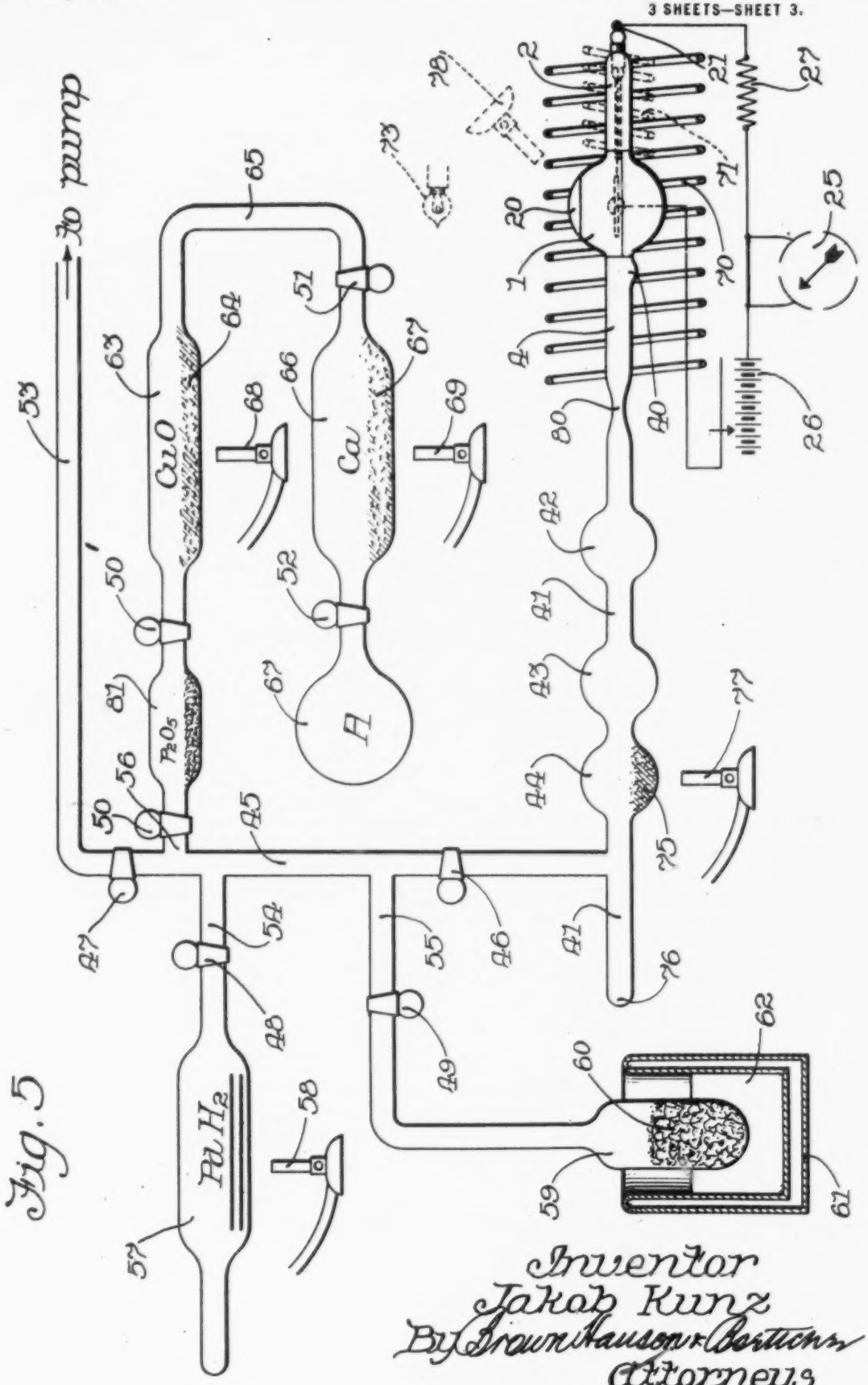

Fig. 5

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Attorneys

UNITED STATES PATENT OFFICE.

JAKOB KUNZ, OF URBANA, ILLINOIS, ASSIGNOR TO BOARD OF TRUSTEES OF THE UNIVERSITY OF ILLINOIS, OF URBANA, ILLINOIS, A CORPORATION OF ILLINOIS.

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The other electrode is placed in the immediate vicinity of the film electrode and is preferably in the form of a screen lying in the path of the entering light, but so constructed as to obstruct the light as little as possible. Between these two electrodes there is formed a field subject to and sensitive to the influence of light.

A cell of this type when properly constructed is characterized by great sensitiveness, uniform sensitiveness over a wide range of light intensities or impressed voltages, not subject to change by aging, rapidity of action, and as I have found by experiment, a straight line characteristic curve.

The human eye is sensitive to light over a range of intensity of substantially from one to 10^{12}, but the cell of my invention may be employed for measuring light intensity beyond either limit of the range of the human eye. Thus for instance, I have found it possible to measure the light given off by a star of the seventh magnitude or the light from a powerful arc.

The cell of my invention is more sensitive to colors than is the human eye and can be employed for distinguishing objects of different colors such as leaves, glass, silks, etc. It appears that the sensitiveness is greater for short wave lengths, as the cell is more sensitive to blue and ultra violet as well as to Roentgen rays.

I prepare the cell by first depositing a silver mirror in contact with the shorter electrode. Then I connect the cell to a system of pipes and chambers comprising a pump for evacuating the cell and containing in one of the chambers an alkali metal and other chambers various gases required. The metal may be any one of the following group:

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Cæsium.

The cell is carefully evacuated and then the metal is distilled upon the silver mirror and in contact with the short electrode, but is carefully kept off of the other electrode. Thereafter, the cell is filled with hydrogen and is subjected to a relatively high electrical potential to cause a glow discharge of electricity. The tube is then pumped out and thereafter filled with argon, nitrogen, neon or other suitable gas, to the proper degree, and is then sealed off.

In order to explain to those skilled in the art how to construct and practice my invention, I shall now describe one embodiment thereof in connection with the accompanying drawings which form a part of the present specification.

Figure 1 is a side elevation of a cell embodying my invention;

Fig. 2 is a longitudinal axial section taken on a plane at right angles to the plane of the sheet in Fig. 1;

Fig. 3 is a diagram illustrating the use of my invention with a source of current in series with the cell;

Fig. 4 is a similar diagram indicating the use of the cell of my invention as a wave detector;

Fig. 5 is a diagrammatic layout of the apparatus and method employed in forming the cell of my invention; and Fig. 6 is a diagram similar to the diagram of Fig. 4.

The cell comprises a glass bulb 1 having a laterally extending arm 2 through which the leading in wire for the screen electrode 3 is introduced. The bulb 1 has an arm 4 lying upon the opposite side and in line with the arm 2 through which the alkali metal for the film electrode 5 is introduced. This leg is also employed for exhausting the bulb 1 and for connecting the same with the various chambers and pipes to be described later. The arm 4 might very well be dispensed with and could be sealed off close to the bulb 1, if desired.

A leading in wire 6 is disposed in a thickened portion 7 of the side walls of the bulb 1. This leading in wire comprises an outer loop 8 and an inner portion which is maintained in contact with the film electrode 5. The film electrode 5 comprises a film or surface of an alkali metal which in this particular instance is potassium. This film of potassium lines substantially the entire inner walls of the bulb with the exception of an opening at the top which is indicated by the line 10 in Fig. 1. The portion of the glass bulb above the line 10 has no coating of potassium metal as this portion of the bulb is left clear for the admission of light to be measured. The film of alkali metal is backed in the lower portion of the bulb by a silver backing or mirror which lies below the line 11 indicated in Fig. 1. This silver mirror is first deposited on the walls of the bulb prior to the distilling of the alkali metal upon the bulb. The silver mirror insures the electrical contact between the alkali film and the leading in wire 6.

The screen electrode 3 comprises a circular ring of metallic wire, in this case silver wire,—which ring is provided with a plurality of cross wires 12 having their ends attached to the ring and being arranged in criss-cross fashion to form a coarse screen. The wires 12 are of very small diameter.

The leading in wire for the screen electrode 3 comprises two sections 13 and 14, respectively. The section 13 passes through the end wall 15 of the arm 2 with a concentric metal sleeve 16 about the same. Between the wire 13 and the sleeve 16 there is a filling of glass 17 for maintaining a tight closure. The wire 13 and the sleeve 16 are made of platinum as this metal has substantially the same coefficient of expansion ring 18, but I prefer to employ silver as the same is equally satisfactory and more plentiful. The wire 14 is covered with a coating of glass 19, this coating serving the double purpose of insulating the wire 14 and of stiffening the same so as to support the screen electrode 3 in proper position.

In Figs. 3, 4 and 6 I have indicated the manner of use of the cell of my invention. As shown in Fig. 3, for the measurement of light from the source L, the photo-electric cell is so placed that light from the source L will enter the clear space or opening 20 in the bulb 1 of the cell and pass through the screen electrode 3 and fall upon the film electrode 5.

The cell is connected in series with an indicator 25 which indicator may be a very sensitive galvanometer. A suitable source of current, such as a storage battery, and a resistance 27 are connected in series with the cell and the indicator 25. The potential of the storage battery may be varied by an adjustable contact mechanism 28 so that the voltage across the terminals of the cell may be varied from about four volts to 120 volts.

I have conducted numerous experiments with cells of this type made up with various alkali metals and filled with various gases or evacuated only, and I have discovered that the cell is suitable for measuring purposes in that over a given range the photo-electric current given off by the cell is proportional to the intensity of illumination to which the cell is subjected. The cell is useful for photometric purposes, particularly in investigations in physics having to do with measurement of the reflection, transmission, radiation and absorption of light under various conditions. The cell is also highly useful in spectroscopy and in astronomy it is particularly useful in the measurement of double star systems in order to ascertain their radius, mass, density, distance and surface brightness. Further uses of the cell of my invention are in plant physiology and photo-chemistry.

For accurate measurement of light for all the above purposes, it is highly desirable that the cells remain constant, that is, not subject to deterioration or change, and that the response of the cell to the light action should be instantaneous and in proportion to the intensity. This I have been able to accomplish by the cell of my invention.

When the cell is in use the platinum cylinder or sleeve 16 is connected to ground, as shown at 30 in Fig. 3, in order to discharge any electricity which may accumulate on the glass surfaces in the stem or arm 2. I consider this construction of the grounded

It is not absolutely essential that a source of current such as 26 be employed in the circuit of the indicator 25, but I find that the operation of the system is more satisfactory when such a source is provided. The indicator 25 may be an electrometer and in that event the resistance 27 is preferably of a high value of the order of between 10^7 and 10^{10} ohms or higher.

I have found that the cell of my invention is a very sensitive wave detector for wireless telegraphy and telephony and the like. When thus employed, the cell is excited by light from the source L, as shown in Fig. 4, so that electrons pass from the film electrode 5 to the screen electrode 3 within the cell. The incoming waves entering by way of the antenna 31 are rectified by the cell and give an indication at the indicator 25 then passing to ground at 32. The source of current 26 may be omitted. The current operating on the indicator 25 may be amplified by an audion or other relay device.

In Fig. 6 I have shown the preferred manner in which I connect the cell for wave detection. The indicator 82 is a string electrometer, which is connected to the terminal 21 of the screen electrode 3. The electrometer is connected to ground through the middle point of the battery 83.

The antenna 31 is connected to the film electrode and also through suitable connections including the inductance 84 and resistance 85 to ground. Suitable capacities 86 and 87 are connected in a manner well understood by those skilled in the art.

I shall now describe one manner in which the cell of my invention may be constructed. The glass bulb 1 with the screen electrode in place and with the silver mirror deposited on the lower part of the bulb with the leading in wires in place is connected by means of the arm 4 to the system shown in Fig. 5. The arm 4 is connected with the horizontal glass tube which has the bulbs or enlargements 42, 43 and 44 therein. The arm 4 is also provided with a small depression or cup 40, the purpose of which will be described later. The horizontal tube 41 is connected to a vertical tube 45 and this vertical tube is connected through the stop cocks 46 and 47 to the pump main 53 and thence to a suitable suction pump for exhausting the air from the system.

Between the stop cocks 46 and 47 a plurality of tubes 54, 55 and 56 lead off to separate chambers, being controlled by the stop cocks 48, 49 and 50, and 50′, respectively.

The connecting tube 54 leads off to a chamber 57 containing palladium which has absorbed a relatively large [illegible] chamber 59 filled with charcoal 60 for absorbing and giving off argon, as will be described later. For this purpose, a double walled receptacle 61 containing liquid air 62 is provided.

The pipe 56 leads to a chamber 81 through a valve 50. This chamber contains phosphorous pentoxid. It in turn leads through the valve 50′ to a chamber or bulb 63 containing copper oxid 64 and this bulb is connected by means of the pipe 65 to another bulb 66 which contains calcium 67, the connection between these bulbs being controlled by a stop cock 51. The chamber 66 is connected through the stop cock 52 with the receptacle 67 which contains argon. The chambers or bulbs 63 and 66 are provided with heating devices such as the burners 68 and 69.

The bulb 1 connected to the horizontal tube 41 is surrounded by a heating coil 70 for heating the entire bulb with both arms 2 and 4. A smaller heating coil 71 shown in dotted lines in Fig. 5 is provided, this coil being adapted to surround the arm 2 for heating the same, as will be described later. The electric circuit including the source of current 26, the galvanometer 25 and resistance 27, is provided for connection to the terminal of the cell at the proper time, as will be described later. A suitable source of light 73 is also provided for testing the cell, after the same is nearing completion.

The outer end of the horizontal tube 41 being open, alkali metal, as indicated at 75, is introduced into the bulb 44. The end of the tube is then sealed at 76. The valves 46—47 are then opened and the valves 48, 49 and 50 are closed and the air pump which is preferably of the mercury type is operated to pump the air out of the system.

The initial depositing of the silver mirror upon the bottom of the bulb may be performed in any of the well known ways, as is understood by those skilled in the art.

After the air has been pumped out of the system the alkali metal 75 is distilled from the bulb 44 into the bulb 43 by heating the bulb 44 with a Bunsen burner as shown at 77 and at the same time cooling the bulb 43. It is apparent that any source of heat other than the Bunsen burner may be employed.

After the air has been pumped out, the heating coil 70 is slipped over the cell and the entire cell is heated to about 177° centigrade and is subjected to the heat for two or three hours to take out all gases which may have been occluded or absorbed in the [illegible]

wave detector;

Fig. 5 is a diagrammatic layout of the apparatus and method employed in forming the cell of my invention; and Fig. 6 is a diagram similar to the diagram of Fig. 4.

The cell comprises a glass bulb 1 having a laterally extending arm 2 through which the leading in wire for the screen electrode 3 is introduced. The bulb 1 has an arm 4 lying upon the opposite side and in line with the arm 2 through which the alkali metal for the film electrode 5 is introduced. This leg is also employed for exhausting the bulb 1 and for connecting the same with the various chambers and pipes to be described later. The arm 4 might very well be dispensed with and could be sealed off close to the bulb 1, if desired.

A leading in wire 6 is disposed in a thickened portion 7 of the side walls of the bulb 1. This leading in wire comprises an outer loop 8 and an inner portion which is maintained in contact with the film electrode 5. The film electrode 5 comprises a film or surface of an alkali metal which in this particular instance is potassium. This film of potassium lines substantially the entire inner walls of the bulb with the exception of an opening at the top which is indicated by the line 10 in Fig. 1. The portion of the glass bulb above the line 10 has no coating of potassium metal as this portion of the bulb is left clear for the admission of light to be measured. The film of alkali metal is backed in the lower portion of the bulb by a silver backing or mirror which lies below the line 11 indicated in Fig. 1. This silver mirror is first deposited on the walls of the bulb prior to the distilling of the alkali metal upon the bulb. The silver mirror insures the electrical contact between the alkali film and the leading in wire 6.

The screen electrode 3 comprises a circular ring of metallic wire, in this case silver wire,—which ring is provided with a plurality of cross wires 12 having their ends attached to the ring and being arranged in criss-cross fashion to form a coarse screen. The wires 12 are of very small diameter.

The leading in wire for the screen electrode 3 comprises two sections 13 and 14, respectively. The section 13 passes through the end wall 15 of the arm 2 with a concentric metal sleeve 16 about the same. Between the wire 13 and the sleeve 16 there is a filling of glass 17 for maintaining a tight closure. The wire 13 and the sleeve 16 are made of platinum as this metal has substantially the same coefficient of expansion as glass.

The wire 14 which is joined to the wire 13 might also be of platinum as could the wire tiful. The wire 14 is covered with a coating of glass 19, this coating serving the double purpose of insulating the wire 14 and of stiffening the same so as to support the screen electrode 3 in proper position.

In Figs. 3, 4 and 6 I have indicated the manner of use of the cell of my invention. As shown in Fig. 3, for the measurement of light from the source L, the photo-electric cell is so placed that light from the source L will enter the clear space or opening 20 in the bulb 1 of the cell and pass through the screen electrode 3 and fall upon the film electrode 5.

The cell is connected in series with an indicator 25 which indicator may be a very sensitive galvanometer. A suitable source of current, such as a storage battery, and a resistance 27 are connected in series with the cell and the indicator 25. The potential of the storage battery may be varied by an adjustable contact mechanism 28 so that the voltage across the terminals of the cell may be varied from about four volts to 120 volts.

I have conducted numerous experiments with cells of this type made up with various alkali metals and filled with various gases or evacuated only, and I have discovered that the cell is suitable for measuring purposes in that over a given range the photo-electric current given off by the cell is proportional to the intensity of illumination to which the cell is subjected. The cell is useful for photometric purposes, particularly in investigations in physics having to do with measurement of the reflection, transmission, radiation and absorption of light under various conditions. The cell is also highly useful in spectroscopy and in astronomy it is particularly useful in the measurement of double star systems in order to ascertain their radius, mass, density, distance and surface brightness. Further uses of the cell of my invention are in plant physiology and photo-chemistry.

For accurate measurement of light for all the above purposes, it is highly desirable that the cells remain constant, that is, not subject to deterioration or change, and that the response of the cell to the light action should be instantaneous and in proportion to the intensity. This I have been able to accomplish by the cell of my invention.

When the cell is in use the platinum cylinder or sleeve 16 is connected to ground, as shown at 30 in Fig. 3, in order to discharge any electricity which may accumulate on the glass surfaces in the stem or arm 2. I consider this construction of the grounded sleeve or cylinder 16 in conjunction with the terminal 21 to be an important structural feature of my invention.

It is not absolutely essential that a source of current such as 26 be employed in the circuit of the indicator 25, but I find that the operation of the system is more satisfactory when such a source is provided. The indicator 25 may be an electrometer and in that event the resistance 27 is preferably of a high value of the order of between 10^7 and 10^{10} ohms or higher.

I have found that the cell of my invention is a very sensitive wave detector for wireless telegraphy and telephony and the like. When thus employed, the cell is excited by light from the source L, as shown in Fig. 4, so that electrons pass from the film electrode 5 to the screen electrode 3 within the cell. The incoming waves entering by way of the antenna 31 are rectified by the cell and give an indication at the indicator 25 then passing to ground at 32. The source of current 26 may be omitted. The current operating on the indicator 25 may be amplified by an audion or other relay device.

In Fig. 6 I have shown the preferred manner in which I connect the cell for wave detection. The indicator 82 is a string electrometer, which is connected to the terminal 21 of the screen electrode 3. The electrometer is connected to ground through the middle point of the battery 83.

The antenna 31 is connected to the film electrode and also through suitable connections including the inductance 84 and resistance 85 to ground. Suitable capacities 86 and 87 are connected in a manner well understood by those skilled in the art.

I shall now describe one manner in which the cell of my invention may be constructed. The glass bulb 1 with the screen electrode in place and with the silver mirror deposited on the lower part of the bulb with the leading in wires in place is connected by means of the arm 4 to the system shown in Fig. 5. The arm 4 is connected with the horizontal glass tube which has the bulbs or enlargements 42, 43 and 44 therein. The arm 4 is also provided with a small depression or cup 40, the purpose of which will be described later. The horizontal tube 41 is connected to a vertical tube 45 and this vertical tube is connected through the stop cocks 46 and 47 to the pump main 53 and thence to a suitable suction pump for exhausting the air from the system.

Between the stop cocks 46 and 47 a plurality of tubes 54, 55 and 56 lead off to separate chambers, being controlled by the stop cocks 48, 49 and 50, and 50′, respectively.

The connecting tube 54 leads off to a chamber 57 containing palladium which has absorbed a relatively large content of hydrogen. A suitable burner 58 is provided for heating the palladium to cause the same to evolve hydrogen when desired.

The tube 55 is connected with a bulb or chamber 59 filled with charcoal 60 for absorbing and giving off argon, as will be described later. For this purpose, a double walled receptacle 61 containing liquid air 62 is provided.

The pipe 56 leads to a chamber 81 through a valve 50. This chamber contains phosphorous pentoxid. It in turn leads through the valve 50′ to a chamber or bulb 63 containing copper oxid 64 and this bulb is connected by means of the pipe 65 to another bulb 66 which contains calcium 67, the connection between these bulbs being controlled by a stop cock 51. The chamber 66 is connected through the stop cock 52 with the receptacle 67 which contains argon. The chambers or bulbs 63 and 66 are provided with heating devices such as the burners 68 and 69.

The bulb 1 connected to the horizontal tube 41 is surrounded by a heating coil 70 for heating the entire bulb with both arms 2 and 4. A smaller heating coil 71 shown in dotted lines in Fig. 5 is provided, this coil being adapted to surround the arm 2 for heating the same, as will be described later. The electric circuit including the source of current 26, the galvanometer 25 and resistance 27, is provided for connection to the terminal of the cell at the proper time, as will be described later. A suitable source of light 73 is also provided for testing the cell, after the same is nearing completion.

The outer end of the horizontal tube 41 being open, alkali metal, as indicated at 75, is introduced into the bulb 44. The end of the tube is then sealed at 76. The valves 46—47 are then opened and the valves 48, 49 and 50 are closed and the air pump which is preferably of the mercury type is operated to pump the air out of the system.

The initial depositing of the silver mirror upon the bottom of the bulb may be performed in any of the well known ways, as is understood by those skilled in the art.

After the air has been pumped out of the system the alkali metal 75 is distilled from the bulb 44 into the bulb 43 by heating the bulb 44 with a Bunsen burner as shown at 77 and at the same time cooling the bulb 43. It is apparent that any source of heat other than the Bunsen burner may be employed.

After the air has been pumped out, the heating coil 70 is slipped over the cell and the entire cell is heated to about 177° centigrade and is subjected to the heat for two or three hours to take out all gases which may have been occluded or absorbed in the glass or in any of the parts of the cell. During all this time the air pump is in operation to carry away such gases or vapors.

The metal which has been distilled in the

bulb 43 is now evaporated therefrom and distilled in the bulb 42. Thereafter, while the pump is still operating and the heat on, the alkali metal is distilled or poured into the enlargement 40 in the arm 4 of the cell. The heating coil 70 is then removed and a smaller heating coil, as shown in dotted lines at 71 is placed about the arm 2 which contains the leading in wire for the screen electrode 3 and the lower portion of the bulb 1 which contains the silver mirror is cooled with water or with ice. A small burner flame is then put below the alkali metal at the point 40 in the stem or arm 4 while the pump is active and while the coil 71 maintains the heat of substantially 150° centigrade upon the arm 2, the interior of the bulb becomes substantially uniformly coated with the alkali metal. When such a coating has been established, the application of heat at the point 40 is stopped and the top of the bulb 1 is heated, as indicated by the burner 78 shown in dotted lines, to drive the alkali metal away from the top of the bulb to form a window for the admission of light. This is to maintain a clear transparent portion 20 through which the light may enter the cell. The heating coil 71 prevents the distillation of any metal in the leg 2 or on the electrode 3. The metal of the electrode conducts heat from the stem or arm 2 thus remaining hot and tending to keep the alkali metal from distilling or condensing thereupon.

After the first layer has been distilled upon the interior of the bulb, another layer is deposited in the same manner, and thereafter the clear space 78 is again heated to drive away the metal vapor. The coating of alkali metal is applied in about three steps in order to secure a uniform layer of the same. The silver mirror tends to maintain a conducting relation between all the particles of the alkali metal which is in fact deposited in minute droplets but which, when the process of distilling is finished, form a continuous layer upon the inside of the cell. It is quite important that the alkali metal be kept out of the stem 2 and off of the positive electrode, otherwise the action of the cell may be interfered with.

Thereafter the valve 47 is closed and with the valves 49 and 50 remaining closed and the valve 46 remaining open, the valve 48 is opened. This connects the bulb or chamber 57 to the system. Hydrogen at a pressure of two or three millimeters is then admitted through the cell, this hydrogen being preferably secured from palladium by heating the same. With the hydrogen remaining in the bulb 1, the source of current [illegible] through the terminals of is an electrical discharge, then occurs in the tube. This potential is employed for only two or three seconds and during that time the electrical discharge causes an interaction between the metal film and the gas which changes the film into a very sensitive state. Just what occurs I am unable to state, but I believe that a hydrate of the alkali metal is produced, or that the metal enters a colloidal state. I have found that it is possible to use dry ammonium gas or ethane and probably other gases may be employed. When the sensitive film is thus formed I test the cell to ascertain its condition. For this purpose I decrease the voltage across the terminals to about 120 volts and energize the source of light 73. The current through the galvanometer 75 is then measured and if the right sensitiveness has been secured, the operation is then finished.

If the sensitiveness is not high enough the potential is increased to about 300 volts and the formation of the layer with hydrogen is continued. It is very easy to pass the most sensitive point and if this occurs the hydrogen is pumped out and a little more of the alkali metal is distilled, as before, and the formation of the film with hydrogen and the electrical discharge is repeated. When the right sensitiveness has been secured, the hydrogen is pumped out of the system, the valve 48 being at this time closed and the valves 46 and 47 open. The valves 47 and 46 are thereafter closed.

The valve 52 is next opened to admit argon from the chamber 67 to the chamber 66. The chamber 66 contains calcium in broken up form and as the argon is admitted to the chamber 66, the calcium is heated with a Bunsen flame or other source of heat, such as electric current. The calcium absorbs any oxygen and nitrogen which may be contained with the argon.

The valve 51 is next opened and the purified argon is then passed to the chamber 63 which contains copper oxid. The copper oxid is heated to substantially red heat and serves to absorb any hydrogen which may be contained in the stream of argon. The pipe 56 has a chamber 81 in which is lodged some phosphorous pentoxid for absorbing any moisture that might be contained in the argon or that might be evolved by heating of the copper-oxid. The valve 50 is then opened to admit argon into the system between the valves 46 and 47, and after the system is substantially filled with argon the valve 50 is again closed. The body of charcoal 60 in the chamber 59 is surrounded with a bath of liquid air at 62 and the valve 49 is opened. The argon which is contained in the system is then absorbed by the char-

rent 26 is connected across the terminals of the cell to impress substantially 120 volts across the same through the galvanometer or electrometer 25. If the body of charcoal 60 does not absorb all of the argon, the same may be removed by means of the air pump.

The valve 46 is thereafter opened and the valve 49 being open, the chamber 61 containing the liquid air 62 is removed from the bulb 59 and the charcoal 60 begins to evolve argon gas. The indicator 25 is then carefully watched as the argon is admitted until the point of maximum deflection is attained. The valve 46 is then closed and the cell is ready to be sealed off at the point 80.

If neon or helium were employed instead of argon, a suitable container for the same would be connected to the system, as indicated by the container 67 which contains argon.

It is not essential that the cell be filled with an inert gas, but I find that greater sensitiveness is secured by doing so.

I do not intend to be limited to the precise details of construction or operation above indicated.

I claim:

1. In combination, a transparent bulb of insulating material, a wire passing through and sealed in the walls of the bulb, a metallic cylinder concentric with the wire and extending through and sealed in the walls of the bulb.

2. In combination, a glass bulb, a wire passing through the walls of the bulb, a metallic cylinder concentric with the wire and extending through the wall of the bulb, said wire being connected to a suitable source of current, and said metallic cylinder being connected to ground.

3. In combination, a glass vessel having a tube integral with and extending therefrom, a wire passing through the wall of said tube, a metallic cylinder concentric with the wire and extending through the wall of the tube, said wire extending through said tube into the glass vessel and a coating of glass on said wire and forming a tight closure between the wire and the cylinder.

4. The method of forming a light sensitive surface in a photo-electric cell which comprises evacuating a glass bulb forming the cell, cooling a portion of the cell externally, introducing the vapor of an alkaline metal into the bulb to deposit a film of metal upon the inner walls of the same and then heating a portion of the cell while another portion is being cooled to drive away the alkaline metal from said heated portion to form a transparent portion.

5. In the formation of a photo-electric cell composing a bulb having an extending arm with an electrode in the bulb supported on a leading-in wire, said wire extending through the arm, the process which comprises evacuating the bulb and arm, introducing the vapor of an alkaline metal into the bulb, cooling a portion of the bulb, and heating the arm to cause heat to be conducted by the leading-in wire to the electrode to prevent deposit of the alkaline metal thereupon.

6. In the formation of a photo-electric cell composing a bulb having an extending arm with an electrode in the bulb supported on a leading-in wire, said wire extending through the arm, the process which comprises, evacuating the bulb and arm, introducing the vapor of an alkaline metal into the bulb, cooling a portion of the bulb, heating the arm to cause heat to be conducted by the leading-in wire to the electrode to prevent deposit of the alkaline metal thereupon, and simultaneously heating a portion of the bulb to form a transparent portion in line with said electrode and the portion which is cooled.

7. The method of depositing a film of alkali metal in a photo-electric cell which comprises cooling a portion of the cell introducing a vapor of the metal to be deposited and heating the portions of the cell upon which no film is to be deposited.

8. The method of forming a photo-electric cell which comprises evacuating the cell, distilling a thin coating of alkali metal upon one electrode only, subjecting said coating to an electric discharge in the presence of hydrogen and then filling the cell with argon and then sealing off the cell.

9. The method of forming a light sensitive film of an alkali metal upon one of the electrodes of a photo-electric cell which comprises filling the cell with vapor of the metal, cooling the one electrode to deposit a film of metal thereupon, and heating the other electrode to prevent the deposit of the metal thereupon.

10. In combination, a leading-in wire, a glass coating on said wire, a cylinder fitting upon and sealed to said glass coating, a glass bulb, said cylinder passing through and being sealed in the walls of said bulb, said cylinder being electrically independent of said leading-in wire.

11. In a device of the class described, a closed tube having a pair of electrodes within the same, a thin film of a suitable light sensitive metal in contact with the walls of the tube and forming one electrode, said thin film lining substantially the entire inner walls of the tube with the exception of an opening in line with the other electrode, whereby substantially all extraneous light other than that to be measured is excluded.

12. In a cell of the class described, [illegible]

distilled in the bulb 42. Thereafter, while the pump is still operating and the heat on, the alkali metal is distilled or poured into the enlargement 40 in the arm 4 of the cell. The heating coil 70 is then removed and a smaller heating coil, as shown in dotted lines at 71 is placed about the arm 2 which contains the leading in wire for the screen electrode 3 and the lower portion of the bulb 1 which contains the silver mirror is cooled with water or with ice. A small burner flame is then put below the alkali metal at the point 40 in the stem or arm 4 while the pump is active and while the coil 71 maintains the heat of substantially 150° centigrade upon the arm 2, the interior of the bulb becomes substantially uniformly coated with the alkali metal. When such a coating has been established, the application of heat at the point 40 is stopped and the top of the bulb 1 is heated, as indicated by the burner 78 shown in dotted lines, to drive the alkali metal away from the top of the bulb to form a window for the admission of light. This is to maintain a clear transparent portion 20 through which the light may enter the cell. The heating coil 71 prevents the distillation of any metal in the leg 2 or on the electrode 3. The metal of the electrode conducts heat from the stem or arm 2 thus remaining hot and tending to keep the alkali metal from distilling or condensing thereupon.

After the first layer has been distilled upon the interior of the bulb, another layer is deposited in the same manner, and thereafter the clear space 78 is again heated to drive away the metal vapor. The coating of alkali metal is applied in about three steps in order to secure a uniform layer of the same. The silver mirror tends to maintain a conducting relation between all the particles of the alkali metal which is in fact deposited in minute droplets but which, when the process of distilling is finished, form a continuous layer upon the inside of the cell. It is quite important that the alkali metal be kept out of the stem 2 and off of the positive electrode, otherwise the action of the cell may be interfered with.

Thereafter the valve 47 is closed and with the valves 49 and 50 remaining closed and the valve 46 remaining open, the valve 48 is opened. This connects the bulb or chamber 57 to the system. Hydrogen at a pressure of two or three millimeters is then admitted through the cell, this hydrogen being preferably secured from palladium by heating the same. With the hydrogen remaining in the bulb 1, the source of current 26 is connected through the terminals of the cell and an electro-motive force of about 300 volts is impressed upon the terminals of the cell. A beautiful golden glow which tube. This potential is employed for only two or three seconds and during that time the electrical discharge causes an interaction between the metal film and the gas which changes the film into a very sensitive state. Just what occurs I am unable to state, but I believe that a hydrate of the alkali metal is produced, or that the metal enters a colloidal state. I have found that it is possible to use dry ammonium gas or ethane and probably other gases may be employed. When the sensitive film is thus formed I test the cell to ascertain its condition. For this purpose I decrease the voltage across the terminals to about 120 volts and energize the source of light 73. The current through the galvanometer 75 is then measured and if the right sensitiveness has been secured, the operation is then finished.

If the sensitiveness is not high enough the potential is increased to about 300 volts and the formation of the layer with hydrogen is continued. It is very easy to pass the most sensitive point and if this occurs the hydrogen is pumped out and a little more of the alkali metal is distilled, as before, and the formation of the film with hydrogen and the electrical discharge is repeated. When the right sensitiveness has been secured, the hydrogen is pumped out of the system, the valve 48 being at this time closed and the valves 46 and 47 open. The valves 47 and 46 are thereafter closed.

The valve 52 is next opened to admit argon from the chamber 67 to the chamber 66. The chamber 66 contains calcium in broken up form and as the argon is admitted to the chamber 66, the calcium is heated with a Bunsen flame or other source of heat, such as electric current. The calcium absorbs any oxygen and nitrogen which may be contained with the argon.

The valve 51 is next opened and the purified argon is then passed to the chamber 63 which contains copper oxid. The copper oxid is heated to substantially red heat and serves to absorb any hydrogen which may be contained in the stream of argon. The pipe 56 has a chamber 81 in which is lodged some phosphorous pentoxid for absorbing any moisture that might be contained in the argon or that might be evolved by heating of the copper-oxid. The valve 50 is then opened to admit argon into the system between the valves 46 and 47, and after the system is substantially filled with argon the valve 50 is again closed. The body of charcoal 60 in the chamber 59 is surrounded with a bath of liquid air at 62 and the valve 49 is opened. The argon which is contained in the system is then absorbed by the charcoal 60.

When the last trace of argon has been absorbed by the charcoal, the source of cur-

rent 26 is connected across the terminals of the cell to impress substantially 120 volts across the same through the galvanometer or electrometer 25. If the body of charcoal 60 does not absorb all of the argon, the same may be removed by means of the air pump.

The valve 46 is thereafter opened and the valve 49 being open, the chamber 61 containing the liquid air 62 is removed from the bulb 59 and the charcoal 60 begins to evolve argon gas. The indicator 25 is then carefully watched as the argon is admitted until the point of maximum deflection is attained. The valve 46 is then closed and the cell is ready to be sealed off at the point 80.

If neon or helium were employed instead of argon, a suitable container for the same would be connected to the system, as indicated by the container 67 which contains argon.

It is not essential that the cell be filled with an inert gas, but I find that greater sensitiveness is secured by doing so.

I do not intend to be limited to the precise details of construction or operation above indicated.

I claim:

1. In combination, a transparent bulb of insulating material, a wire passing through and sealed in the walls of the bulb, a metallic cylinder concentric with the wire and extending through and sealed in the walls of the bulb.

2. In combination, a glass bulb, a wire passing through the walls of the bulb, a metallic cylinder concentric with the wire and extending through the wall of the bulb, said wire being connected to a suitable source of current, and said metallic cylinder being connected to ground.

3. In combination, a glass vessel having a tube integral with and extending therefrom, a wire passing through the wall of said tube, a metallic cylinder concentric with the wire and extending through the wall of the tube, said wire extending through said tube into the glass vessel and a coating of glass on said wire and forming a tight closure between the wire and the cylinder.

4. The method of forming a light sensitive surface in a photo-electric cell which comprises evacuating a glass bulb forming the cell, cooling a portion of the cell externally, introducing the vapor of an alkaline metal into the bulb to deposit a film of metal upon the inner walls of the same and then heating a portion of the cell while another portion is being cooled to drive away the alkaline metal from said heated portion to form a transparent portion.

5. In the formation of a photo-electric cell comprising a bulb having an extending arm with an electrode in the bulb supported on a leading-in wire, said wire extending through the arm, the process which comprises evacuating the bulb and arm, introducing the vapor of an alkaline metal into the bulb, cooling a portion of the bulb, and heating the arm to cause heat to be conducted by the leading-in wire to the electrode to prevent deposit of the alkaline metal thereupon.

6. In the formation of a photo-electric cell composing a bulb having an extending arm with an electrode in the bulb supported on a leading-in wire, said wire extending through the arm, the process which comprises, evacuating the bulb and arm, introducing the vapor of an alkaline metal into the bulb, cooling a portion of the bulb, heating the arm to cause heat to be conducted by the leading-in wire to the electrode to prevent deposit of the alkaline metal thereupon, and simultaneously heating a portion of the bulb to form a transparent portion in line with said electrode and the portion which is cooled.

7. The method of depositing a film of alkali metal in a photo-electric cell which comprises cooling a portion of the cell introducing a vapor of the metal to be deposited and heating the portions of the cell upon which no film is to be deposited.

8. The method of forming a photo-electric cell which comprises evacuating the cell, distilling a thin coating of alkali metal upon one electrode only, subjecting said coating to an electric discharge in the presence of hydrogen and then filling the cell with argon and then sealing off the cell.

9. The method of forming a light sensitive film of an alkali metal upon one of the electrodes of a photo-electric cell which comprises filling the cell with vapor of the metal, cooling the one electrode to deposit a film of metal thereupon and heating the other electrode to prevent the deposit of the metal thereupon.

10. In combination, a leading-in wire, a glass coating on said wire, a cylinder fitting upon and sealed to said glass coating, a glass bulb, said cylinder passing through and being sealed in the walls of said bulb, said cylinder being electrically independent of said leading-in wire.

11. In a device of the class described, a closed tube having a pair of electrodes within the same, a thin film of a suitable light sensitive metal in contact with the walls of the tube and forming one electrode, said thin film lining substantially the entire inner walls of the tube with the exception of an opening-in line with the other electrode, whereby substantially all extraneous light other than that to be measured is excluded.

12. In a cell of the class described, a closed chamber of substantially spherical form having an interior coating of a light sensitive alkali metal except for a small portion forming a window, and a flat screen elec-

trode lying at the center of the chamber and at substantially right angles to the light rays admitted through the window whereby a substantially uniform field is formed between the coating and the screen.

13. In a cell of the class described, a bulb having a hollow substantially cylindrical arm extending laterally therefrom, an electrode comprising a metallic ring lying within the bulb with its axis in the direction of the rays of light which act upon the cell, a wire extending from said ring through said arm and terminating outside the wall of the end of the arm, said ring having a plurality of fine wires connected thereto to form a screen within the ring, a silver mirror coating one side of the bulb, a leading in wire passing through the wall of the bulb and connecting with the silver mirror, and a coating of sensitized alkali metal deposited upon the silver mirror and upon the walls of the bulb except a relatively small portion of the bulb in line with the axis of the ring for the admission of light, said coating of alkali metal forming a light sensitive electrode and preventing the accumulation of a static charge upon the walls of the bulb.

14. In a photo-electric cell, a spherical bulb having a substantially cylindrical hollow arm extending laterally therefrom, an electrode comprising a metallic ring lying centrally within the bulb with its axis in the direction of the rays of light which act upon the cell, a wire extending from said ring through said arm and terminating outside the end wall of the arm, a glass coating upon said wire, a metallic sleeve covering said glass coating where the wire passes through the end wall of the arm said sleeve extending beyond the sides of the end wall of the arm both internally and externally to prevent any creepage of electricity over either the external or internal walls of the bulb between electrodes, a metallic mirror coating one side of the bulb, a leading in wire passing through the side wall of the bulb at substantially right angles to the axis of said ring and being in electrical connection with said mirror, and a plural coating of sensitized alkali metal deposited upon the silver mirror and the inner walls of the bulb excepting a small portion of the bulb in line with the axis of the ring for the admission of light, said coating of alkali metal forming a light sensitive electrode and preventing the accumulation of a static charge upon the walls of the bulb.

15. In a device of the class described, a bulb, an electrode in the bulb, a glass stem for the electrode having a wire running therethrough and connected to the electrode, and a metallic coating for the outer end of the stem said bulb forming a seal with the stem on said metallic coating, a second electrode projecting through a wall of the bulb, said metallic coating being interposed between the electrodes to prevent surface creepage of electricity along either the external surface or the internal surface of the bulb.

16. The method of depositing an alkali metal in a photo-electric cell from a vessel which comprises connecting the vessel containing the alkali metal through a plurality of chambers with the cell, evacuating the cell and progressively distilling the alkali metal from the vessel through the chambers successively while the cell is being evacuated and finally into the cell.

17. The method of depositing an alkali metal in a photo-electric cell from a vessel, which comprises distilling the metal in a plurality of successive steps toward and finally into the cell and repeating the distillation to form a plurality of coatings upon the interior of the cell, said distillation being carried on while the cell is evacuated.

18. In a cell of the class described, a closed glass bulb having a photo sensitive interior coating of alkaline metal over the major portion thereof forming one electrode, and a flat screen electrode placed substantially at the center of the bulb and at right angles to the light admitted to the electrode whereby a substantially uniform field is formed between the electrodes.

In witness whereof I hereunto subscribe my name this 17 day of August 1918.

JAKOB KUNZ.

1174

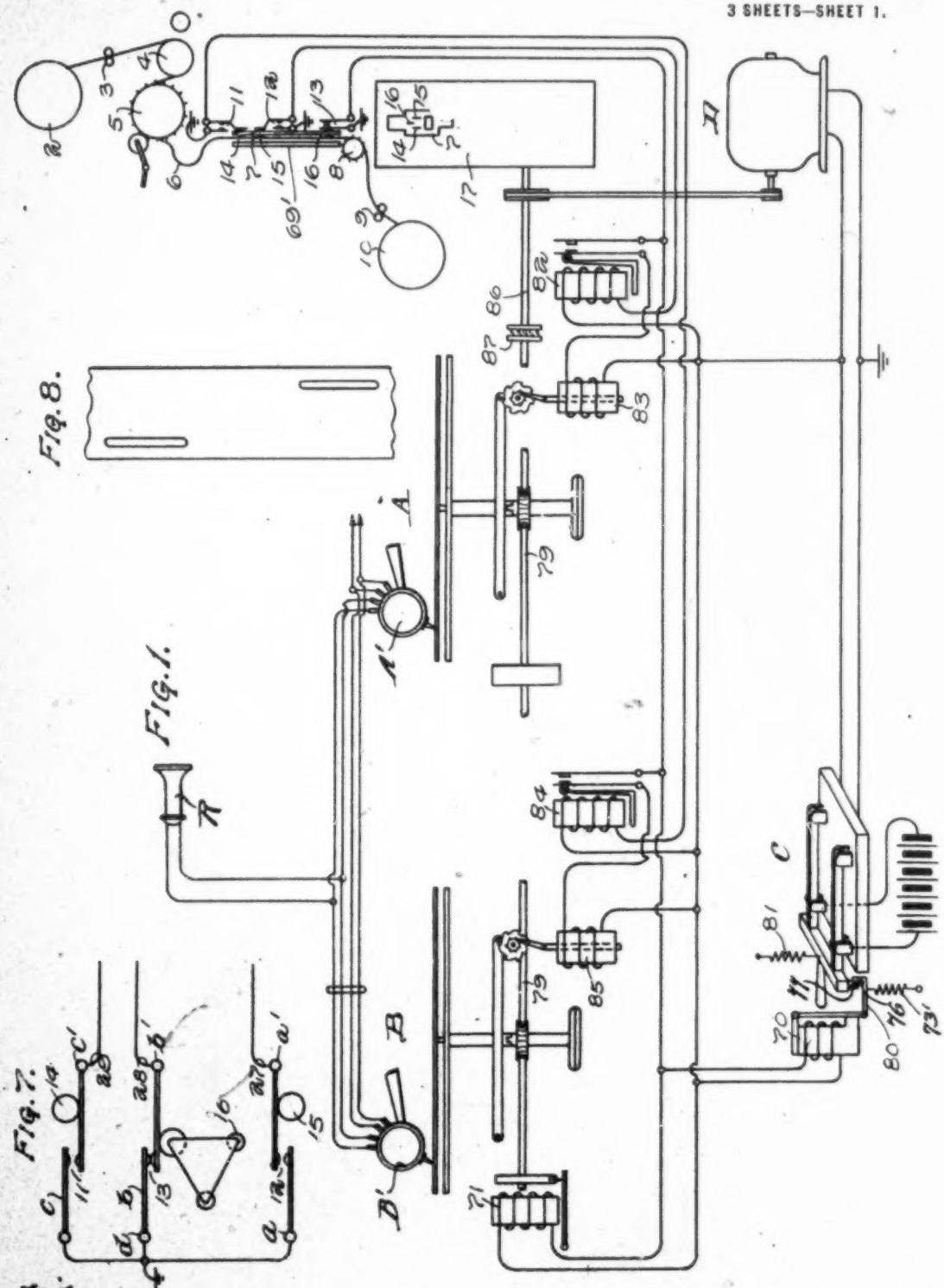
W. M. CLARK.

TALKING MOVING PICTURE APPARATUS.

APPLICATION FILED JULY 12, 1915. RENEWED MAY 23, 1921.

1,388,515. Patented Aug. 23, 1921.

3 SHEETS—SHEET 1.



Witness:-

INVENTOR.

W. M. CLARK.

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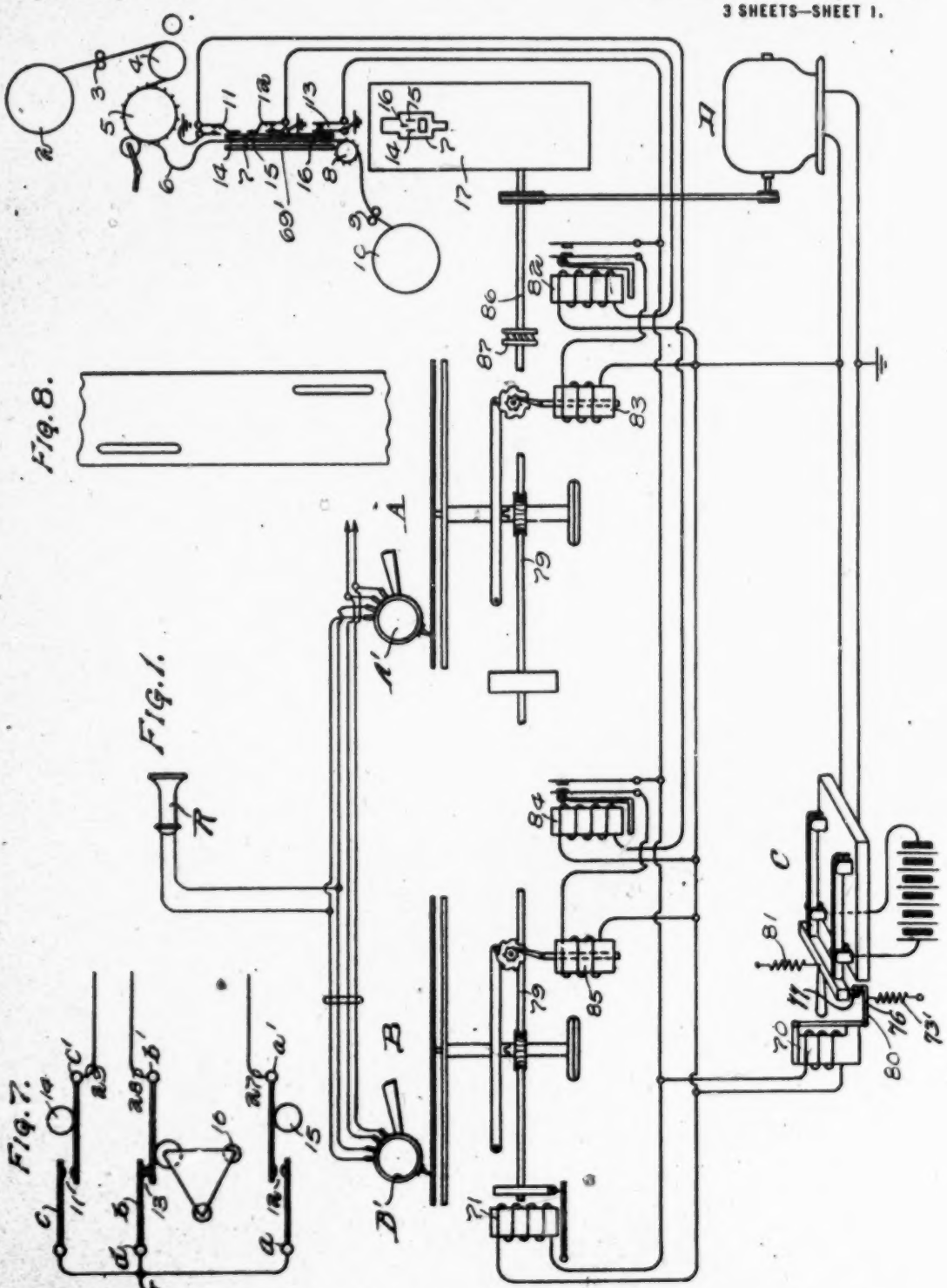


Fig. 8.

Fig. 1.

Fig. 7.

Witness:-
R. B. Richardson
B. Garber

INVENTOR:
W. M. Clark
By Hale.
ATTORNEY.

1176

W. M. CLARK.

TALKING MOVING PICTURE APPARATUS.

APPLICATION FILED JULY 12, 1915. RENEWED MAY 23, 1921.

1,388,515.

Patented Aug. 23, 1921.

3 SHEETS—SHEET 2.

Fig. 3.

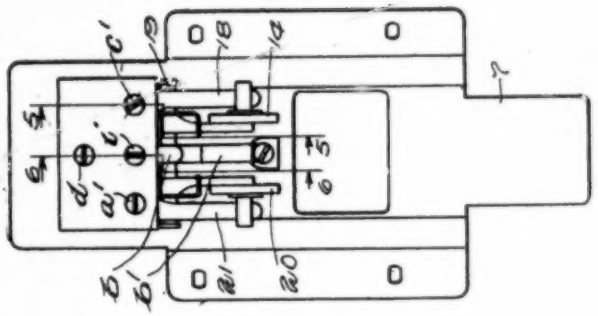


Fig. 5.

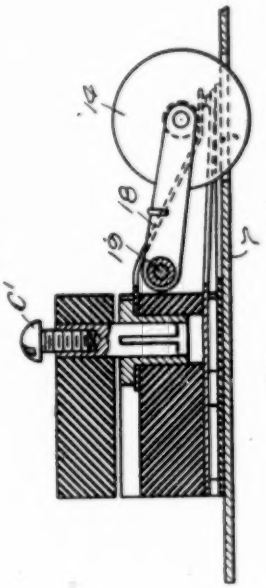


Fig. 4.

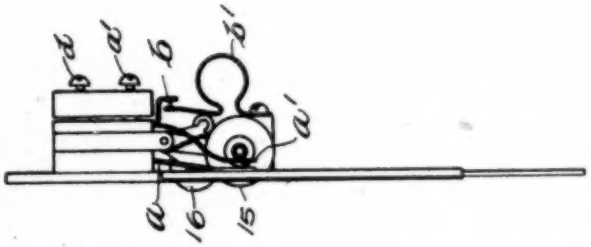


Fig. 2.

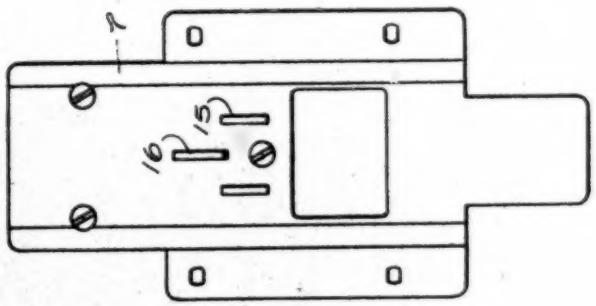
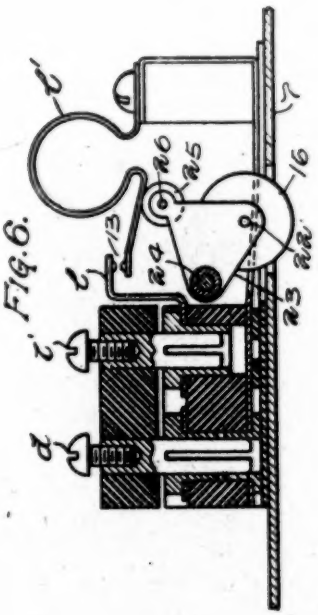


Fig. 6.



Witnesses:-

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INVENTOR:

W. M. Clark

W. M. CLARK.

TALKING MOVING PICTURE APPARATUS.

APPLICATION FILED JULY 12, 1918. RENEWED MAY 25, 1921.

1,388,515. Patented Aug. 23, 1921.

3 SHEETS—SHEET 2.

Fig. 3.

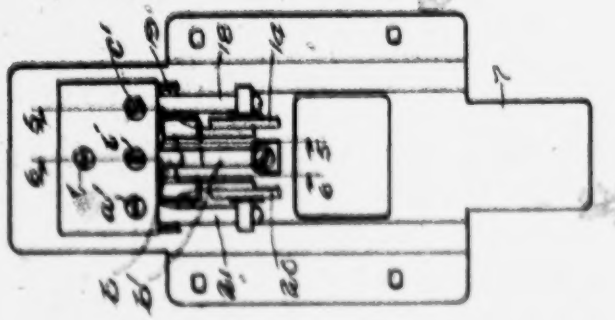


Fig. 5.

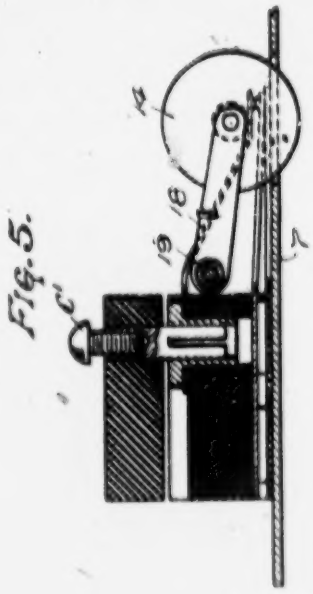


Fig. 4.

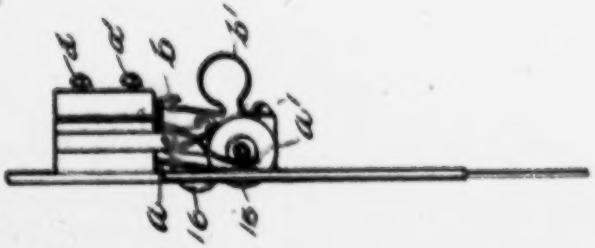


Fig. 8.

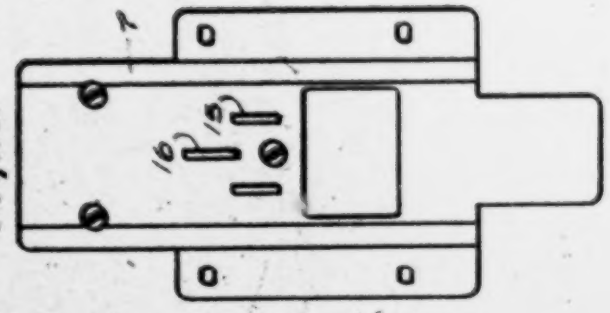
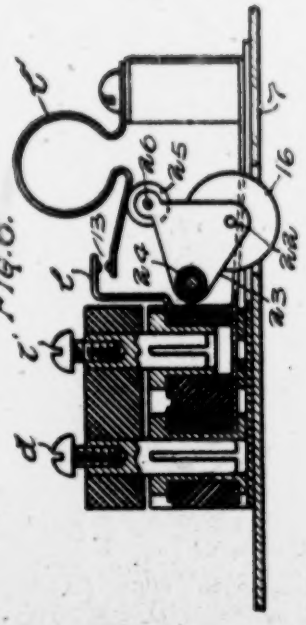


Fig. 6.



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1178

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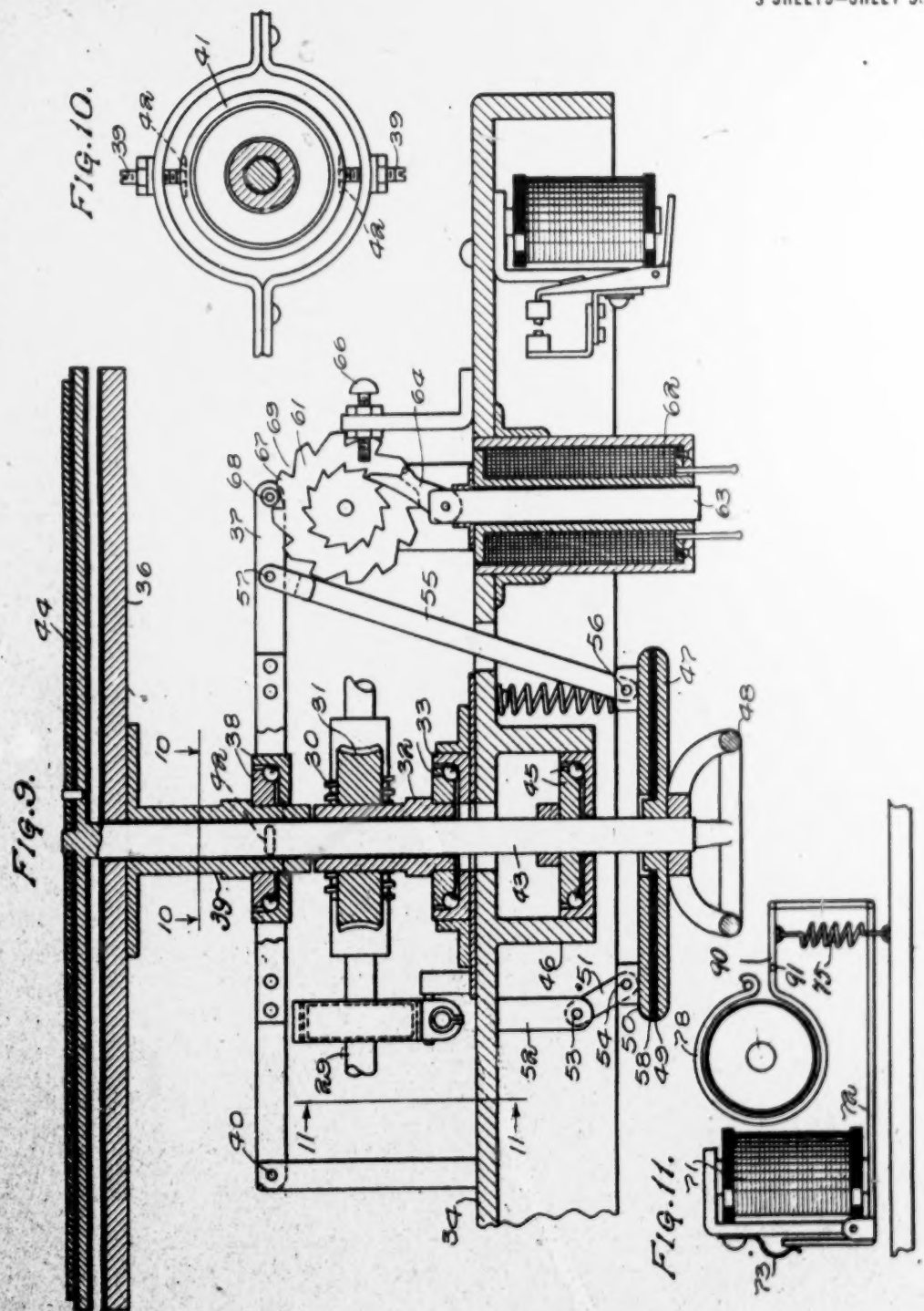
TALKING MOVING PICTURE APPARATUS.

APPLICATION FILED JULY 12, 1915. RENEWED MAY 23, 1921.

1,388,515. Patented Aug. 23, 1921.

3 SHEETS—SHEET 3.



Witness:-

INVENTOR:

UNITED STATES PATENT OFFICE.

WILLIAM M. CLARK, OF CHICAGO, ILLINOIS.

TALKING MOVING-PICTURE APPARATUS.

1,388,515. Specification of Letters Patent. Patented Aug. 23, 1921.

Application filed July 12, 1915, Serial No. 39,326. Renewed May 23, 1921. Serial No. 471,968.

To all whom it may concern:

Be it known that I, WILLIAM M. CLARK, a citizen of the United States of America, and resident of Chicago, Cook county, Illinois, have invented a certain new and useful Improvement in Talking Moving-Picture Apparatus, of which the following is a specification.

My invention relates to an improved form of phonographic apparatus which is specially applicable for use in connection with moving picture apparatus. Heretofore there has been a great deal of difficulty in working phonographic apparatus satisfactorily in synchronism with a moving picture projector, and I have a device and new means for running the two in a satisfactory and reliable manner.

Among the objects of my invention are: the provision of improved means for controlling the phonographic apparatus from films; the provision of means whereby all of the controlling means allotted to the projector is mounted upon the aperture plate; the provision of means, in a device of the above character in which the phonograph apparatus is driven by higher speed mechanism than the projector shaft, for applying a brake to the higher speed mechanism for stopping both the phonographic equipment and the projector equipment; the provision of a special brake between the point of application of the brake and the projector driving shaft; and the provision of certain details and features of improvement tending to increase the efficiency and serviceability of apparatus of the above character.

To accomplish the foregoing and other useful ends I provide means hereinafter more fully set forth and claimed.

Figure 1 is a lay-out showing in a general way the relation between the projector, film, circuits, and other devices for controlling the phonographic apparatus.

Fig. 2 shows the aperture plate in front view.

Fig. 3 is a rear view of the same.

Fig. 4 is a side view of the same.

Fig. 5 is a section on line 5—5, Fig. 3.

Fig. 9 shows in detail the driving and controlling mechanism in the phonograph apparatus.

Fig. 10 is a detail of one of the bearings in Fig. 9, showing how the casing is pivoted.

Fig. 11 shows in detail the mechanism of a Raymond brake magnet.

Referring to the drawing, Fig. 1, the film is shown extending from the reel 2 through the fire rollers 3, around the tension roller 4 and around the sprocket wheel 5, beyond which it forms the loop 6, after which it passes through the aperture plate 7, and thence around the intermittent sprocket wheel 8 and fire wheel 9 to the intake wheel 10. Behind the aperture plate 7 there are provided three sets of springs, 11, 12 and 13.

The springs 11 are controlled by a roller 14 which is mounted on one end of a pivoted arm or spring and normally tend to assume a position inside a corresponding slot in the aperture plate due to the tension from one of the springs 11 or from any other suitable spring. Similarly the springs 12 are controlled by a roller 15 which also normally, and for the same reason, tends to assume a position within a slot in the aperture plate. Likewise the springs 13 are controlled by a roller 16, which also normally tends to assume a position within a slot in the aperture plate. When the film is in position, however, these rollers are ordinarily pressed back as shown in Fig. 1. In this figure, the springs 11, 12 and 13 are not shown in their actual relative positions. However, within the square 17, which represents the projector, the aperture plate 7 is shown in front view and the true relative positions of the rollers 14, 15 and 16 are shown, behind which, of course, the springs which they control are mounted. Each one of the rollers 14, 15 and 16 is provided with a ridge on the periphery, which engages the film. Along the film at suitable intervals there are provided apertures or punctures, one set in line with each one of the ridges. Whenever a puncture arrives opposite a ridge the ridge drops through the film thereby causing the springs behind the roller to vary their position. Some of these springs

TALKING MOVING PICTURE APPARATUS.

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3 SHEETS—SHEET 3.

FIG. 10.

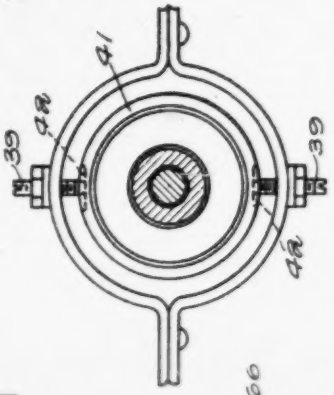

FIG. 9.

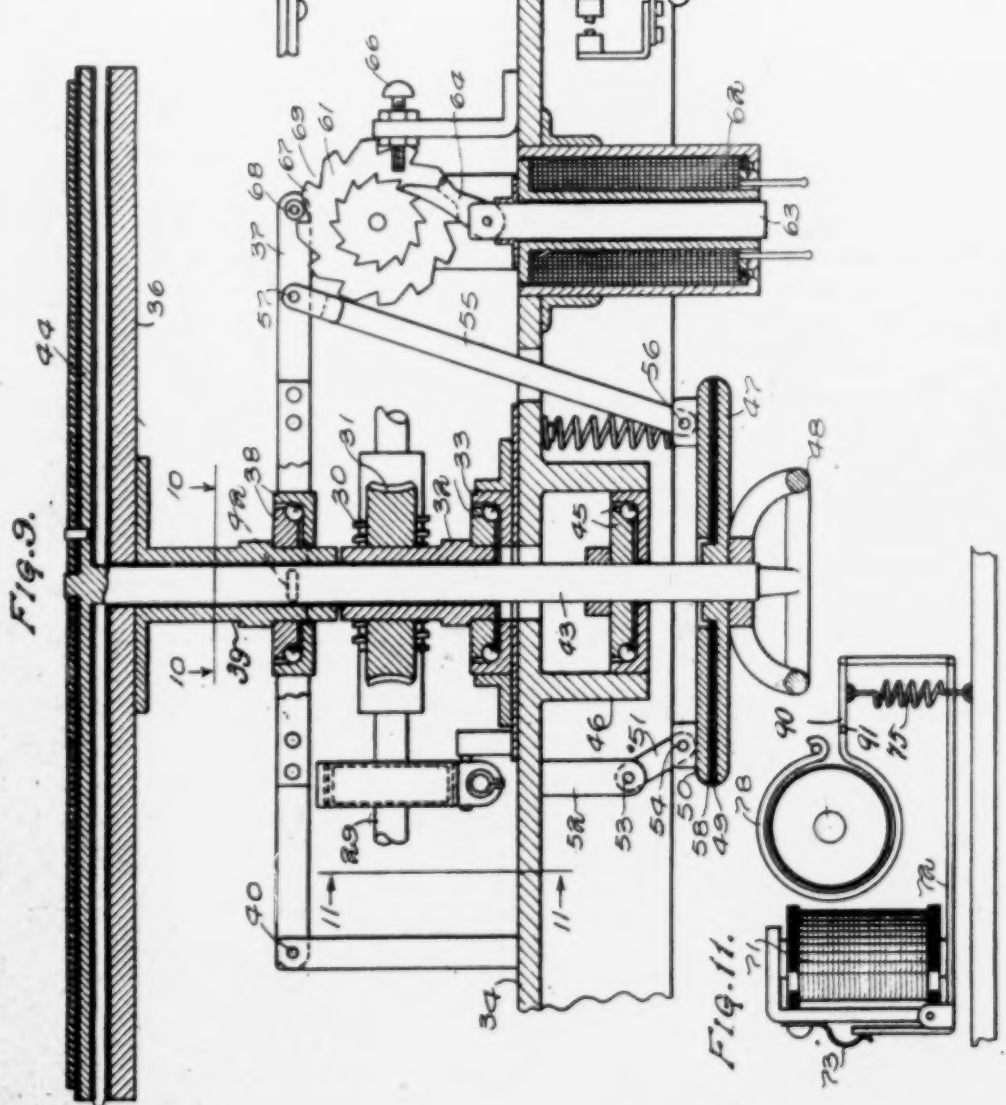

FIG. 11.

Witnesses:-
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UNITED STATES PATENT OFFICE.

WILLIAM M. CLARK, OF CHICAGO, ILLINOIS.

TALKING MOVING-PICTURE APPARATUS.

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My invention relates to an improved form of phonographic apparatus which is specially applicable for use in connection with moving picture apparatus. Heretofore there has been a great deal of difficulty in working phonographic apparatus satisfactorily in synchronism with a moving picture projector, and I have a device and new means for running the two in a satisfactory and reliable manner.

Among the objects of my invention are: the provision of improved means for controlling the phonographic apparatus from films; the provision of means whereby all of the controlling means allotted to the projector is mounted upon the aperture plate; the provision of means, in a device of the above character in which the phonograph apparatus is driven by higher speed mechanism than the projector shaft, for applying a brake to the higher speed mechanism for stopping both the phonographic equipment and the projector equipment; the provision of a special brake between the point of application of the brake and the projector driving shaft; and the provision of certain details and features of improvement tending to increase the efficiency and serviceability of apparatus of the above character.

To accomplish the foregoing and other useful ends I provide means hereinafter more fully set forth and claimed.

Figure 1 is a lay-out showing in a general way the relation between the projector, film, circuits, and other devices for controlling the phonographic apparatus.

Fig. 2 shows the aperture plate in front view.

Fig. 3 is a rear view of the same.

Fig. 4 is a side view of the same.

Fig. 5 is a section on line 5—5, Fig. 3.

Fig. 6 is a section on line 6—6, Fig. 3.

Fig. 7 shows diagrammatically the circuit connections on the aperture plate.

Fig. 8 shows the film with the controlling aperture openings therein.

Fig. 9 shows in detail the driving and controlling mechanism in the phonograph apparatus.

Fig. 10 is a detail of one of the bearings in Fig. 9, showing how the casing is pivoted.

Fig. 11 shows in detail the mechanism of a Raymond brake magnet.

Referring to the drawing, Fig. 1, the film is shown extending from the reel 2 through the fire rollers 3, around the tension roller 4 and around the sprocket wheel 5, beyond which it forms the loop 6, after which it passes through the aperture plate 7, and thence around the intermittent sprocket wheel 8 and fire wheel 9 to the intake wheel 10. Behind the aperture plate 7 there are provided three sets of springs, 11, 12 and 13.

The springs 11 are controlled by a roller 14 which is mounted on one end of a pivoted arm or spring and normally tend to assume a position inside a corresponding slot in the aperture plate due to the tension from one of the springs 11 or from any other suitable spring. Similarly the springs 12 are controlled by a roller 15 which also normally, and for the same reason, tends to assume a position within a slot in the aperture plate. Likewise the springs 13 are controlled by a roller 16, which also normally tends to assume a position within a slot in the aperture plate. When the film is in position, however, these rollers are ordinarily pressed back as shown in Fig. 1. In this figure, the springs 11, 12 and 13 are not shown in their actual relative positions. However, within the square 17, which represents the projector, the aperture plate 7 is shown in front view and the true relative positions of the rollers 14, 15 and 16 are shown, behind which, of course, the springs which they control are mounted. Each one of the rollers 14, 15 and 16 is provided with a ridge on the periphery, which engages the film. Along the film at suitable intervals there are provided apertures or punctures, one set in line with each one of the ridges. Whenever a puncture arrives opposite a ridge the ridge drops through the film thereby causing the springs behind the roller to vary their position. Some of these springs are so adjusted that when its controlling wheel meets a puncture a circuit is closed. Another wheel when it meets a puncture may cause a circuit to be opened. In each one of the circuits which is controlled by each one

of these rollers there may be provided any suitable electromagnet for controlling any suitable apparatus.

For example, associated with the aperture plate 7 there are shown in Fig. 1 a couple of phonographs A and B and also a circuit breaker C.

As the circuits indicate the phonograph A is controlled through the medium of the springs 12 and the roller 15; the phonograph B is controlled through the medium of the springs 11 and the roller 14; whereas the circuit breaker C is controlled through the medium of the springs 13 and the roller 16.

In Fig. 2, the aperture plate 7 is shown in larger dimensions and, therefore, shows the relative location of the rollers and it also shows, of course, the windows in the aperture plate through which the rollers project into the path of the film.

Referring to Figs. 2, 3, 4, 5, 6 and 7, it will be seen that the roller 14 is rotatably mounted on the end of the arm 18, which arm is pivotally sustained on the shaft 19. Similarly, the roller 15 is rotatably mounted on the arm 21, which is in turn pivotally mounted upon the pin 19. On the other hand the roller 16 (see Fig. 6) is rotatably mounted on the pin 22 on the triangular frame 23. This triangular frame is pivotally mounted on the pin 24 and it carries on the corner opposite the one that carries the roller 16 an auxiliary roller 25 rotatably mounted on the pin 26.

Referring to Fig. 7, it will be seen that the springs *a*, *b* and *c* are all connected to a common terminal and to the grounded end of the battery, whereas the corresponding springs *a'*, *b'* and *c'* are connected respectively to the circuit conductors 27, 28 and 28'. It will be seen also that all of the springs *a*, *b* and *c* have a common terminal *d*.

The mechanism through the medium of which the phonograph is controlled is as follows: Referring to Fig. 9 the shaft 29 is the driving shaft and carries a worm gear 30. This worm gear engages the gear wheel 31, which is rigidly secured to the hollow shaft 32. This shaft 32 is sustained by the bearings 33, which is in turn secured to a main frame 34. Locked in driving engagement with the shaft 32 is the hollow shaft 35, to which is permanently secured the fly wheel 36. This shaft 35 may be raised and lowered, while in driving engagement with the shaft 32, through the medium of the lever 37. Upon this lever 37 is pivotally the housing 41 of the bearings 38 in horizontal slots 42, so as to permit the trunnions 39 to move from left to right and from right to left, as the lever 37 rises and falls. Within the hollow shafts 32 and 35 there is a shaft 43, to the upper end of which there is attached the disk supporting plate 44. This shaft and disk are made of light material, so as to insure a low inertia, in order that the plate 44 may be started and stopped very quickly. The shaft 43 is provided with bearings 45 in a suitable housing 46, which is built upon the under side of the main frame 34. Near the lower end of the shaft 43 there is provided a disk 47, which is permanently fixed to the shaft. Below this disk there is provided a hand wheel 48 for controlling the shaft 43. On the upper surface of the plate 47 there is provided a leather surface 49. Just above this leather surface there is a plate 50 supported by the link 51 to the post 52, which is a part of the frame 34. This link 51 is pivoted at the points 53 and 54. The plate 50 is also sustained by another link 55, which is secured to the lever 37. This link 55 is pivoted at the points 56 and 57. The under side of the plate 50 is also provided with a leather surface 58. The upper side of the fly wheel 36 is provided with a leather surface 59, while the under side of the record holding disk 44 is likewise provided with a leather surface 60. The lever 37 is controlled by a cam wheel 61, which wheel is in turn controlled by the solenoid 62, the core 63 of which carries a pawl 64. It will be seen that when the shaft 29 is rotated, the fly wheel 36 is rotated through the medium of the worm 30, gear wheel 31, and shafts 32 and 35. Now if the solenoid 62 is energized, the plunger 63 raises the pawl 64, which latter by engaging the tooth wheel 64 rotates the cam wheel 61 until the pawl 64 strikes the bumping post 66. As a result, the tooth 67 on the cam wheel 61 by engaging the roller 68 on the lever 37, raises the lever, the roller 68 resting for the time being on the top of the tooth 67, even though the magnet 62 deënergizes and the plunger 63 be withdrawn. As a result of raising the lever 37, the fly wheel 36 is raised into engagement with the disk 44, whereupon the disk 44 immediately starts rotating with the fly wheel 36 and at the same speed. This occurs with practically no slipping between the surfaces 59 and 60, and therefore the disk 44 attains its maximum speed almost instantly, and in fact, instantly for all prac-

and at the same time the plate 50 at the other end of the shaft is carried into engagement with the shaft disk 47, thereby bringing the disk 44 instantly to a standstill.

Having described the mechanism in detail, it will now be explained how the automatic control of the phonographic equipment is carried on from the film. Assuming that the film has been set in place and that the projector has started (Fig. 1), and that the proper phonographic records which are to be used in connection with the film have been placed in position on the turn tables A and B, the automatic operation is as follows: As soon as the film is placed in position and the fire door 69′ opposite the aperture plate is closed, the rollers 13, 14 and 15 are pressed in with the result that the spring contacts 11 and 12 are opened, whereas the spring contact 13 is closed. As a result of the closure of the spring 13 an energizing circuit is closed through the circuit breaker magnet 70 and through the Raymond brake magnet 71 (see Fig. 11).

As soon as magnet 71 energizes, armature 72 is attracted against the tension of the spring 73, thereby causing the right hand end of the lever 90 to rotate about a pivot 91 against the tension of the spring 75, thereby causing the pressure of the clamp 78 on the shaft 79 to be relieved. The attendant now throws in a circuit breaker switch C; and since the magnet 70 is energized the circuit is held closed by the latch on the end of the armature 80, against the tension of the spring 81. As soon as the switch C is thrown in the motor D begins to operate thereby driving the shaft 79 thereby starting the projector and the phonographic apparatus.

As the film advances an aperture on the film in line with the roller 15 permits the ridge on the circumference of the roller 15 to fall through thereby permitting the springs 12 to close, thus energizing the relay 82 which in turn closes the energizing circuit for the operating solenoid 83 of the phonograph A. This solenoid is the same as the solenoid 62. As a result the phonograph A is brought into operation. It will be understood that the closure of the springs 12 is only momentary as the aperture is only a short one. The springs 12 are immediately separated again but not until the phonograph A has been locked so as to continue operation until the next aperture again operates the roller 15, whereupon the magnet [illegible] tion, and continues in operation until another aperture throws it out. Therefore the phonographs A and B may be thrown out either together or independently off and on during the operation of the film and made to work in synchronism therewith. If for any reason the film breaks the circuit at the springs 13, under the control of the roller 16, is broken whereupon the brake magnet 71 and the circuit breaker magnet 70 deënergized. The former applies a brake to the shaft 79 since the spring 75 is now free to act, and the latter, since the spring 73′ is now at liberty to withdraw the catch 76 from behind the terminal 77, throws out the circuit breaker C thereby cutting off the current from the motor D.

As I have indicated in Fig. 1, the various phonographs A, B, etc., may be provided with reproducers A′, B′, etc., of the type shown in United States Letters Patent No. 1,185,877, which reproducers may be connected up in multiple so that they may in common have one or more receivers such as the receiver R in Fig. 1. These reproducers may be connected up with circuits as illustrated in United States Letters Patent No. 1,084,070, Fig. 1. The reproducers of the type shown are provided with two differential microphones, one on each side of the central diaphragm. Each one of these differential microphones is supplied with a circuit such as shown in Fig. 1 of the last mentioned patent. If there are several phonographs all of these differential microphones would be connected in multiple, for example, to the receiver circuit, which receiver circuit, it will be seen, is represented in the said last mentioned patent extending over two conductors to the magnet *b*.

It will be seen therefore that I provide an entirely efficient method of linking up a phonograph set with any moving picture machine of the standard type. All that I have to do is to remove the aperture plate with which the machine is supplied and substitute instead the aperture plate which constitutes the terminal of the cable that contains the conductors 27, 28 and 28′ over which the phonographic apparatus is controlled. Then by lining up the phonograph control shaft 79 with the projector shaft 86 through the medium of any suitable coupler 87, I am ready to get synchronized service between the two devices. This can be done in just a few minutes. This is the first time that means has been provided for coupling

of these rollers there may be provided any suitable electromagnet for controlling any suitable apparatus.

For example, associated with the aperture plate 7 there are shown in Fig. 1 a couple of phonographs A and B and also a circuit breaker C.

As the circuits indicate the phonograph A is controlled through the medium of the springs 12 and the roller 15; the phonograph B is controlled through the medium of the springs 11 and the roller 14; whereas the circuit breaker C is controlled through the medium of the springs 13 and the roller 16.

In Fig. 2, the aperture plate 7 is shown in larger dimensions and, therefore, shows the relative location of the rollers and it also shows, of course, the windows in the aperture plate through which the rollers project into the path of the film.

Referring to Figs. 2, 3, 4, 5, 6 and 7, it will be seen that the roller 14 is rotatably mounted on the end of the arm 18, which arm is pivotally sustained on the shaft 19. Similarly, the roller 15 is rotatably mounted on the arm 21, which is in turn pivotally mounted upon the pin 19. On the other hand the roller 16 (see Fig. 6) is rotatably mounted on the pin 22 on the triangular frame 23. This triangular frame is pivotally mounted on the pin 24 and it carries on the corner opposite the one that carries the roller 16 an auxiliary roller 25 rotatably mounted on the pin 26.

Referring to Fig. 7, it will be seen that the springs *a*, *b* and *c* are all connected to a common terminal and to the grounded end of the battery, whereas the corresponding springs *a'*, *b'* and *c'* are connected respectively to the circuit conductors 27, 28 and 28'. It will be seen also that all of the springs *a*, *b* and *c* have a common terminal *d*.

The mechanism through the medium of which the phonograph is controlled is as follows: Referring to Fig. 9 the shaft 29 is the driving shaft and carries a worm gear 30. This worm gear engages the gear wheel 31, which is rigidly secured to the hollow shaft 32. This shaft 32 is sustained by the bearings 33, which is in turn secured to a main frame 34. Locked in driving engagement with the shaft 32 is the hollow shaft 35, to which is permanently secured the fly wheel 36. This shaft 35 may be raised and lowered, while in driving engagement with the shaft 32, through the medium of the lever 37. Upon this lever 37 is pivotally mounted the bearings 38, which sustain the shaft 35. These bearings, as shown in Fig. 10, are supported by the trunnions 39, so that the rotary movements of the lever 37 about the pivot 40 to which the shaft is secured will not operate to throw the shaft 35 out of alinement. The trunnions 39 engage the housing 42 of the bearings so as to horizontal slots 42, so as to permit the trunnions 39 to move from left to right and from right to left, as the lever 37 rises and falls. Within the hollow shafts 32 and 35 there is a shaft 43, to the upper end of which there is attached the disk supporting plate 44. This shaft and disk are made of light material, so as to insure a low inertia, in order that the plate 44 may be started and stopped very quickly. The shaft 43 is provided with bearings 45 in a suitable housing 46, which is built upon the under side of the main frame 34. Near the lower end of the shaft 43 there is provided a disk 47, which is permanently fixed to the shaft. Below this disk there is provided a hand wheel 48 for controlling the shaft 43. On the upper surface of the plate 47 there is provided a leather surface 49. Just above this leather surface there is a plate 50 supported by the link 51 to the post 52, which is a part of the frame 34. This link 51 is pivoted at the points 53 and 54. The plate 50 is also sustained by another link 55, which is secured to the lever 37. This link 55 is pivoted at the points 56 and 57. The under side of the plate 50 is also provided with a leather surface 58. The upper side of the fly wheel 36 is provided with a leather surface 59, while the under side of the record holding disk 44 is likewise provided with a leather surface 60. The lever 37 is controlled by a cam wheel 61, which wheel is in turn controlled by the solenoid 62, the core 63 of which carries a pawl 64. It will be seen that when the shaft 29 is rotated, the fly wheel 36 is rotated through the medium of the worm 30, gear wheel 31, and shafts 32 and 35. Now if the solenoid 62 is energized, the plunger 63 raises the pawl 64, which latter by engaging the tooth wheel 64 rotates the cam wheel 61 until the pawl 64 strikes the bumping post 66. As a result, the tooth 67 on the cam wheel 61 by engaging the roller 68 on the lever 37, raises the lever, the roller 68 resting for the time being on the top of the tooth 67, even though the magnet 62 deënergizes and the plunger 63 be withdrawn. As a result of raising the lever 37, the fly wheel 36 is raised into engagement with the disk 44, whereupon the disk 44 immediately starts rotating with the fly wheel 36 and at the same speed. This occurs with practically no slipping between the surfaces 59 and 60, and therefore the disk 44 attains its maximum speed almost instantly, and in fact, instantly for all practical purposes. This rotation of the disk 44 continues until the magnet 62 is energized again, whereupon the pawl 64 advances the cam wheel 61 another step, with the result that the roller 68 on the arm 37 falls in the notch 69. When this occurs the fly wheel 36 disengages from the plate 44,

and at the same time the plate 50 at the other end of the shaft is carried into engagement with the shaft disk 47, thereby bringing the disk 44 instantly to a standstill.

Having described the mechanism in detail, it will now be explained how the automatic control of the phonographic equipment is carried on from the film. Assuming that the film has been set in place and that the projector has started (Fig. 1), and that the proper phonographic records which are to be used in connection with the film have been placed in position on the turn tables A and B, the automatic operation is as follows: As soon as the film is placed in position and the fire door 69′ opposite the aperture plate is closed, the rollers 13, 14 and 15 are pressed in with the result that the spring contacts 11 and 12 are opened, whereas the spring contact 13 is closed. As a result of the closure of the spring 13 an energizing circuit is closed through the circuit breaker magnet 70 and through the Raymond brake magnet 71 (see Fig. 11).

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As the film advances an aperture on the film in line with the roller 15 permits the ridge on the circumference of the roller 15 to fall through thereby permitting the springs 12 to close, thus energizing the relay 82 which in turn closes the energizing circuit for the operating solenoid 83 of the phonograph A. This solenoid is the same as the solenoid 62. As a result the phonograph A is brought into operation. It will be understood that the closure of the springs 12 is only momentary as the aperture is only a short one. The springs 12 are immediately separated again but not until the phonograph A has been locked so as to continue operation until the next aperture again operates the roller 15, whereupon the magnet 83 is again energized and the phonograph A thrown out. In a similar manner the apertures on the same film in line with the roller 14 control the relay 84 which in turn controls the operating magnet 85, which latter is the same of course, as the magnet 83 of the phonograph A. In this manner the phonograph B may be brought into operation, and continues in operation until another aperture throws it out. Therefore the phonographs A and B may be thrown out either together or independently off and on during the operation of the film and made to work in synchronism therewith. If for any reason the film breaks the circuit at the springs 13, under the control of the roller 16, is broken whereupon the brake magnet 71 and the circuit breaker magnet 70 deënergized. The former applies a brake to the shaft 79 since the spring 75 is now free to act, and the latter, since the spring 73′ is now at liberty to withdraw the catch 76 from behind the terminal 77, throws out the circuit breaker C thereby cutting off the current from the motor D.

As I have indicated in Fig. 1, the various phonographs A, B, etc., may be provided with reproducers A′, B′, etc., of the type shown in United States Letters Patent No. 1,185,877, which reproducers may be connected up in multiple so that they may in common have one or more receivers such as the receiver R in Fig. 1. These reproducers may be connected up with circuits as illustrated in United States Letters Patent No. 1,084,070, Fig. 1. The reproducers of the type shown are provided with two differential microphones, one on each side of the central diaphragm. Each one of these differential microphones is supplied with a circuit such as shown in Fig. 1 of the last mentioned patent. If there are several phonographs all of these differential microphones would be connected in multiple, for example, to the receiver circuit, which receiver circuit, it will be seen, is represented in the said last mentioned patent extending over two conductors to the magnet *b*.

It will be seen therefore that I provide an entirely efficient method of linking up a phonograph set with any moving picture machine of the standard type. All that I have to do is to remove the aperture plate with which the machine is supplied and substitute instead the aperture plate which constitutes the terminal of the cable that contains the conductors 27, 28 and 28′ over which the phonographic apparatus is controlled. Then by lining up the phonograph control shaft 79 with the projector shaft 86 through the medium of any suitable coupler 87, I am ready to get synchronized service between the two devices. This can be done in just a few minutes. This is the first time that means has been provided for coupling up the two classes of apparatus without having to make any material alterations or changes in the projector.

It will thus be seen that I have provided a highly improved means for operating in conjunction a moving picture projector and phonographic apparatus. It will be seen further that this highly improved means

makes it possible for the first time to quickly slap together and start operating any two equipments, the one requisite being the provision of a film with the proper punctures and the replacement of the aperture plate with the plate that constitutes the cable terminal.

I provide means also for the first time, under the control of the film, for a brake which is applied instantly that the film breaks, so as to bring the whole equipment to a standstill without having the projector and the phonograph equipment drop out of synchronism. Otherwise when the film breaks the phonographic equipment would stop independently of the projector equipment and throw the thing out of synchronism to that extent, and in the case of rupture of the film due to fire, the continued operation of the projector would merely feed down so much more of the film beyond the fire rollers, thereby feeding just that much more fuel to the flame, thus making it necessary after the attendant has patched up the film, to go to work and bring the equipment into synchronism before starting up again. It will be understood that the object in having the roller 16 higher than the rollers 14 and 15 is to insure the operation of the circuit breaker C before the broken film reaches the rollers 14 and 15. With this arrangement the circuit breaker has time to operate to disconnect the operating current from the whole system, and particularly from the relays 82 and 84 and from magnets 83 and 85, thereby insuring that the phonographic and the projector equipment are left in synchronism, notwithstanding interruption due to the breaking of the film.

It will be seen also that the motor D directly and without any intervening gearing mechanism is made to drive the common driving line of shafting containing the sections 86 and 79. The moving picture machine being of a standard type is provided with a step-down gearing between the projector shaft and the shaft 86. It will be seen also that there is a step-down gearing between the shaft 79 and the phonographs A, B, etc. On the shaft 79 I provide a fly wheel for the purpose of providing inertia sufficiently to protect the phonographs against the vibrations or variations due to the operation of the projector and due to the variations in voltage from the main line beyond the circuit breaker C. I am the first one to provide a common driving shaft directly driven by a motor supplied directly from a commercial circuit, said shaft being graphic equipment from the variations above mentioned.

It is thought that the applicant is a pioneer along this line and that he is entitled to broad claims.

What I claim as my invention is:

1. The combination of a switch operating moving picture film, a plate parallel to said film, a plurality of switches mounted on said plate, each switch having an element in the path of the film and controlled thereby, a circuit individual to each switch, a phonograph individual to each circuit and controlled thereover, a microphone controlled by each phonograph, a circuit common to said microphones, and a receiver under the control of said microphones in common, a driving element for operating the film and for operating the phonographs, and means controlled by one of said switches for stopping the driving element.

2. In a moving picture machine, a shaft, a film controlled thereby, an electrically controlled driving mechanism for said shaft, a circuit for supplying said mechanism with operating current, a circuit breaker in said circuit, a magnet for controlling said circuit breaker, a circuit for said magnet under the control of said film whereby if the film breaks said circuit breaker is operated to open the supply circuit, and a brake associated with said shaft, a magnet for controlling said brake, a circuit for said magnet, said circuit under the control of said film whereby if a film breaks the shaft is brought to a standstill by the application of said brake.

3. In a moving picture machine, a shaft, a film and a phonograph driven thereby, means for driving the shaft, a circuit for controlling said means, a circuit controlled for said circuit whereby if the film breaks said circuit controller is operated to stop the driving mechanism, a brake associated with said shaft, a circuit for controlling said brake, said circuit under the control of said film, whereby if the film breaks the shaft and phonograph are brought to a standstill simultaneously.

4. In a moving picture machine, a shaft, a film and a phonograph driven thereby, means for driving the shaft, a brake associated with said shaft, a circuit for controlling said brake, said circuit under the control of said film, whereby if the film breaks the shaft and phonograph are brought to a standstill instantly through the medium of said brake.

5. The combination of a moving picture machine and a phonograph, a film for the

phonograph, and means controlled by the film for stopping the motor through the medium of said circuit breaker and for applying said brake whereby the phonograph and moving picture machine may be brought to an immediate standstill.

6. The combination of a moving picture machine and a phonograph, a film for the moving picture, a motor for driving the phonograph and moving picture, a circuit for said motor, a circuit breaker for said circuit, a brake for positively stopping said machine and phonograph, and a common circuit for said brake and circuit breaker controlled by the film for stopping the motor and applying said brake whereby the phonograph and film may be brought to a standstill.

7. In combination with a moving picture machine and a plurality of phonographs, of a common driving shaft for driving said machine and phonographs, a clutch for each phonograph for connecting said phonographs successively or simultaneously with said driving shaft, a motor, having a circuit, for driving said shaft, a circuit breaker for said circuit, a brake for stopping said shaft, and film controlled switches for controlling said clutches, brake and circuit breaker in any desired succession, whereby the film and phonograph are maintained in synchronism.

8. The combination of a moving picture machine and a phonograph having a common driving shaft for operating the machine and phonograph, and means for bringing said phonograph successively into engagement with said driving shaft and maintaining the phonograph in synchronism with the film, a plurality of switches controlled by the film, and means controlled by certain of said switches for stopping the machine and by certain others for removing the phonographs from engagement with the driving shaft and at the same time applying a brake which stops said phonographs instantly.

Signed by me at Chicago, Illinois, this 28 day of June, 1915.

W. M. CLARK.

Witnesses:
W. W. OWEN,
HERBERT W. KRAEKE.

makes it possible for the first time to quickly slap together and start operating any two equipments, the one requisite being the provision of a film with the proper punctures and the replacement of the aperture plate with the plate that constitutes the cable terminal.

I provide means also for the first time, under the control of the film, for a brake which is applied instantly that the film breaks, so as to bring the whole equipment to a standstill without having the projector and the phonograph equipment drop out of synchronism. Otherwise when the film breaks the phonographic equipment would stop independently of the projector equipment and throw the thing out of synchronism to that extent, and in the case of rupture of the film due to fire, the continued operation of the projector would merely feed down so much more of the film beyond the fire rollers, thereby feeding just that much more fuel to the flame, thus making it necessary after the attendant has patched up the film, to go to work and bring the equipment into synchronism before starting up again. It will be understood that the object in having the roller 16 higher than the rollers 14 and 15 is to insure the operation of the circuit breaker C before the broken film reaches the rollers 14 and 15. With this arrangement the circuit breaker has time to operate to disconnect the operating current from the whole system, and particularly from the relays 82 and 84 and from magnets 83 and 85, thereby insuring that the phonographic and the projector equipment are left in synchronism, notwithstanding interruption due to the breaking of the film.

It will be seen also that the motor D directly and without any intervening gearing mechanism is made to drive the common driving line of shafting containing the sections 86 and 79. The moving picture machine being of a standard type is provided with a step-down gearing between the projector shaft and the shaft 86. It will be seen also that there is a step-down gearing between the shaft 79 and the phonographs A, B, etc. On the shaft 79 I provide a fly wheel for the purpose of providing inertia sufficiently to protect the phonographs against the vibrations or variations due to the operation of the projector and due to the variations in voltage from the main line beyond the circuit breaker C. I am the first one to provide a common driving shaft directly driven by a motor supplied directly from a commercial circuit, said shaft being emloyed for driving both a phonograph machine and a moving picture machine. I am the first one to utilize inertia in this common driving shaft for protecting the phonographic equipment from the variations above mentioned.

It is thought that the applicant is a pioneer along this line and that he is entitled to broad claims.

What I claim as my invention is:

1. The combination of a switch operating moving picture film, a plate parallel to said film, a plurality of switches mounted on said plate, each switch having an element in the path of the film and controlled thereby, a circuit individual to each switch, a phonograph individual to each circuit and controlled thereover, a microphone controlled by each phonograph, a circuit common to said microphones, and a receiver under the control of said microphones in common, a driving element for operating the film and for operating the phonographs, and means controlled by one of said switches for stopping the driving element.

2. In a moving picture machine, a shaft, a film controlled thereby, an electrically controlled driving mechanism for said shaft, a circuit for supplying said mechanism with operating current, a circuit breaker in said circuit, a magnet for controlling said circuit breaker, a circuit for said magnet under the control of said film whereby if the film breaks said circuit breaker is operated to open the supply circuit, and a brake associated with said shaft, a magnet for controlling said brake, a circuit for said magnet, said circuit under the control of said film whereby if a film breaks the shaft is brought to a standstill by the application of said brake.

3. In a moving picture machine, a shaft, a film and a phonograph driven thereby, means for driving the shaft, a circuit for controlling said means, a circuit controlled for said circuit whereby if the film breaks said circuit controller is operated to stop the driving mechanism, a brake associated with said shaft, a circuit for controlling said brake, said circuit under the control of said film, whereby if the film breaks the shaft and phonograph are brought to a standstill simultaneously.

4. In a moving picture machine, a shaft, a film and a phonograph driven thereby, means for driving the shaft, a brake associated with said shaft, a circuit for controlling said brake, said circuit under the control of said film, whereby if the film breaks the shaft and phonograph are brought to a standstill instantly through the medium of said brake.

5. The combination of a moving picture machine and a phonograph, a film for the moving picture, a motor for driving the phonograph and moving picture, a circuit for said motor, a circuit breaker for said circuit, a brake for stopping said machine and

phonograph, and means controlled by the film for stopping the motor through the medium of said circuit breaker and for applying said brake whereby the phonograph and moving picture machine may be brought to an immediate standstill.

6. The combination of a moving picture machine and a phonograph, a film for the moving picture, a motor for driving the phonograph and moving picture, a circuit for said motor, a circuit breaker for said circuit, a brake for positively stopping said machine and phonograph, and a common circuit for said brake and circuit breaker controlled by the film for stopping the motor and applying said brake whereby the phonograph and film may be brought to a standstill.

7. In combination with a moving picture machine and a plurality of phonographs, of a common driving shaft for driving said machine and phonographs, a clutch for each phonograph for connecting said phonographs successively or simultaneously with said driving shaft, a motor, having a circuit, for driving said shaft, a circuit breaker for said circuit, a brake for stopping said shaft, and film controlled switches for controlling said clutches, brake and circuit breaker in any desired succession, whereby the film and phonograph are maintained in synchronism.

8. The combination of a moving picture machine and a phonograph having a common driving shaft for operating the machine and phonograph, and means for bringing said phonograph successively into engagement with said driving shaft and maintaining the phonograph in synchronism with the film, a plurality of switches controlled by the film, and means controlled by certain of said switches for stopping the machine and by certain others for removing the phonographs from engagement with the driving shaft and at the same time applying a brake which stops said phonographs instantly.

Signed by me at Chicago, Illinois, this 28 day of June, 1915.

W. M. CLARK.

Witnesses:
W. W. OWEN,
HERBERT W. KRAEKE.

1186

J. P. CONSTABLE.
DRIVING CONNECTION.
APPLICATION FILED JUNE 24, 1918.

1,425,177. Patented Aug. 8, 1922.

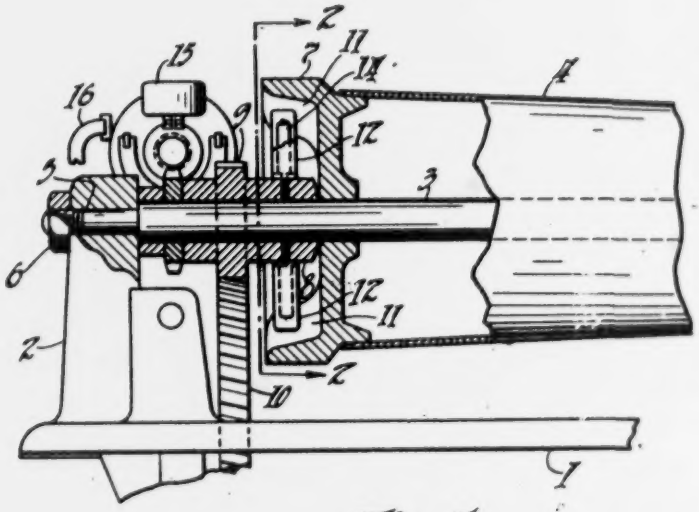

Fig. 1

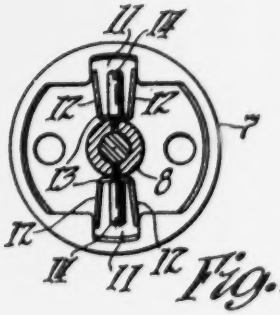

Fig. 2

Witnesses:
A. D. Fisher
Chas. H. Kesler

Inventor:
John P. Constable
By Delos Holden
his Atty.

1187

UNITED STATES PATENT OFFICE.

JOHN P. CONSTABLE, OF WEST ORANGE, NEW JERSEY, ASSIGNOR TO NEW JERSEY PATENT COMPANY, OF WEST ORANGE, NEW JERSEY, A CORPORATION OF NEW JERSEY.

DRIVING CONNECTION.

1,425,177. Specification of Letters Patent. Patented Aug. 8, 1922.

Original application filed August 9, 1915, Serial No. 44,389. Divided and this application filed June 24, 1918. Serial No. 241,672.

To all whom it may concern:

Be it known that I, JOHN P. CONSTABLE, a citizen of the United States, and a resident of Llewellyn Park, West Orange, county of Essex, and State of New Jersey, have invented certain new and useful Improvements in Driving Connections, of which the following is a description.

My invention relates to driving connections, and more particularly to an improved driving connection interposed between a driving means and a record support or mandrel of a phonograph or talking machine.

This application is a division of application Serial No. 44,389, filed by me August 9, 1915.

The object of my invention is to provide an improved device of the character referred to, whereby uniform movement of the record support or other driven means is insured.

In order that my invention may be more clearly understood, attention is hereby directed to the accompanying drawing forming a part of this specification, and in which:

Figure 1 is a view partly in front elevation and partly in section with parts broken away, showing the preferred embodiment of my invention; and

Figure 2 is a view partly in elevation and partly in section taken on the line 2—2 of Figure 1 and looking in the direction of the arrows.

In all of the views, like parts are designated by the same reference numerals.

Referring to Figure 1, a phonographic base or bedplate 1 is provided adjacent to one end thereof with a vertical standard 2, in the upper end of which is mounted a shaft 3 on which is rotatably mounted a driven member or mandrel 4. The end of the shaft 3 supported in the standard 2 is reduced, as shown at 5, the outer end of the reduced portion being threaded and carrying a nut 6 which bears against the side of the standard. The nut 6 and the shoulder between the reduced portion 5 and the body portion of the shaft 3 thereby prevent longitudinal movement of the shaft. Rotataby mounted upon the shaft 3 and extending from the standard

Referring to the figures, the head 7 is provided with diametrically opposed recesses 11 opening inwardly and facing the member 8 and in which are arranged the ends of radially extending arms 12 of non-rectilinear or, more specifically, U-shaped springs 13 which are secured intermediate their ends to the rotatable member 8 by suitable means, such as the radial screws or pins 14 which are threaded through the central portions of the springs 13 into the member 8. The screws 14 are in axial alignment and are so arranged as to normally lie midway between the arms of the springs 13. The ends of the springs 13 normally bear lightly against the sides of the recesses 11. The sides constitute abutments facing each other. In placing a record upon the record support or mandrel 4 it frequently happens that the said support or mandrel is twisted to a considerable extent, and to limit the movement of the mandrel or support 4 relatively to the member 8 so as to prevent the displacement of the ends of the springs 13 from the recesses 11, suitable stops may be provided. In the preferred embodiment of the invention, the heads of the screws 14 are utilized for this purpose and are made of sufficient length to engage the sides of the recesses 11 when the mandrel is rotated a fixed amount relatively to the member 8. During the operation of the phonograph, even if the motor moves irregularly or vibrates to an appreciable extent, the irregular movement or vibration will not be imparted to the record support because of the yielding character of the springs 13, which, while they apply the necessary turning force to the record support and record, permit the said support and record to move under the influence of their momentum with the necessary uniformity. When the phonograph is in normal operation with the parts in motion, the stops 14 are entirely out of engagement with the head 7.

It will be noticed that the gear 10 is a spiral gear, the use of which insures a smoother and less noisy operation of the phonograph than would be secured if ordinary spur gears were employed. A governor 15 is shown connected to the

J. P. CONSTABLE.

DRIVING CONNECTION.

APPLICATION FILED JUNE 24, 1918.

1,425,177.

Patented Aug. 8, 1922.

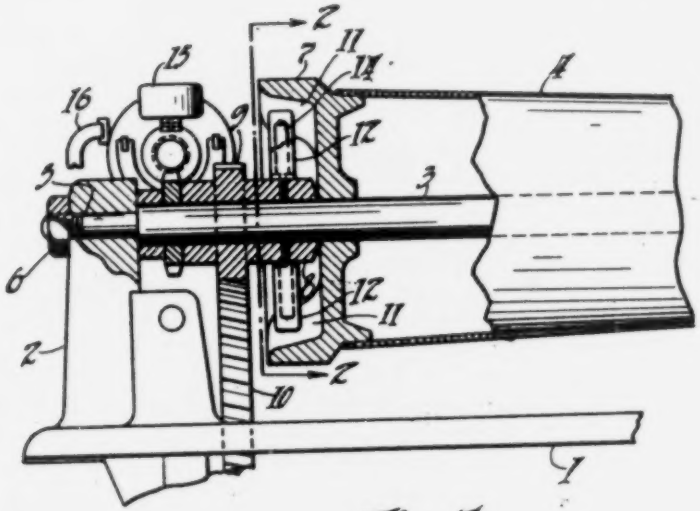

Fig. 1

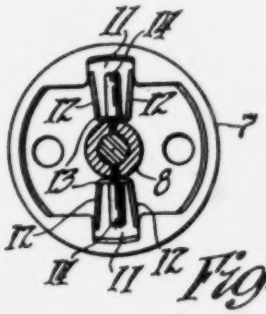

Fig. 2

Witnesses:
N. L. Fisher
Chas. H. Kesler

Inventor:
John P. Constable
By Delos Holden
His Atty.

JOHN P. CONSTABLE, OF WEST ORANGE, NEW JERSEY, ASSIGNOR TO NEW JERSEY PATENT COMPANY, OF WEST ORANGE, NEW JERSEY, A CORPORATION OF NEW JERSEY.

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The object of my invention is to provide an improved device of the character referred to, whereby uniform movement of the record support or other driven means is insured.

In order that my invention may be more clearly understood, attention is hereby directed to the accompanying drawing forming a part of this specification, and in which:

Figure 1 is a view partly in front elevation and partly in section with parts broken away, showing the preferred embodiment of my invention; and

Figure 2 is a view partly in elevation and partly in section taken on the line 2—2 of Figure 1 and looking in the direction of the arrows.

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Referring to Figure 1, a phonographic base or bedplate 1 is provided adjacent to one end thereof with a vertical standard 2, in the upper end of which is mounted a shaft 3 on which is rotatably mounted a driven member or mandrel 4. The end of the shaft 3 supported in the standard 2 is reduced, as shown at 5, the outer end of the reduced portion being threaded and carrying a nut 6 which bears against the side of the standard. The nut 6 and the shoulder between the reduced portion 5 and the body portion of the shaft 3 thereby prevent longitudinal movement of the shaft. Rotataby mounted upon the shaft 3 and extending from the standard 2 to the head 7 at one end of the mandrel 4 is a driving member 8 which is provided with teeth to form a pinion 9. This pinion meshes with a gear 10 which in turn is rotated by a motor, not shown.

Referring to the figures, the head 7 is provided with diametrically opposed recesses 11 opening inwardly and facing the member 8 and in which are arranged the ends of radially extending arms 12 of non-rectilinear or, more specifically, U-shaped springs 13 which are secured intermediate their ends to the rotatable member 8 by suitable means, such as the radial screws or pins 14 which are threaded through the central portions of the springs 13 into the member 8. The screws 14 are in axial alignment and are so arranged as to normally lie midway between the arms of the springs 13. The ends of the springs 13 normally bear lightly against the sides of the recesses 11. The sides constitute abutments facing each other. In placing a record upon the record support or mandrel 4 it frequently happens that the said support or mandrel is twisted to a considerable extent, and to limit the movement of the mandrel or support 4 relatively to the member 8 so as to prevent the displacement of the ends of the springs 13 from the recesses 11, suitable stops may be provided. In the preferred embodiment of the invention, the heads of the screws 14 are utilized for this purpose and are made of sufficient length to engage the sides of the recesses 11 when the mandrel is rotated a fixed amount relatively to the member 8. During the operation of the phonograph, even if the motor moves irregularly or vibrates to an appreciable extent, the irregular movement or vibration will not be imparted to the record support because of the yielding character of the springs 13, which, while they apply the necessary turning force to the record support and record, permit the said support and record to move under the influence of their momentum with the necessary uniformity. When the phonograph is in normal operation with the parts in motion, the stops 14 are entirely out of engagement with the head 7.

It will be noticed that the gear 10 is a spiral gear, the use of which insures a smoother and less noisy operation of the phonograph than would be secured if ordinary spur gears were employed. A governor 15 is shown connected to the member 8 to regulate the speed of the motor. This governor is provided with a brake 16 whereby the motion of the governor and the movable parts connected thereto may be arrested. The brake 16 can be positioned to hold the

governor and driving means, including the gear 9, stationary during the rewinding of the motor.

It is to be understood that my invention is not limited to the embodiments and features specifically shown and described herein, but that such features and embodiments are subject to changes and modifications without any departure from the spirit of the invention.

Having now described my invention, what I claim as new and desire to protect by Letters Patent is as follows:

1. The combination of movable members, and a spring having connection intermediate its ends with one of said members, having arms extending substantially radially in the same general direction from said connection, and coacting at said ends with the other of said members, substantially as described.

2. The combination of movable members, abutments on one member facing each other, and a substantially U-shaped spring connected intermediate its ends to the other member, and having said ends extending between said abutments, substantially as described.

3. The combination of relatively movable members, a non-rectilinear spring connected intermediate its ends to one of said members and having radially extending arms coacting at said ends with the other member and a stop for limiting relative movement between the members, substantially as described.

4. The combination of relatively movable members, a spring between said members and a pin securing said spring to one member and constituting a stop for limiting relative movement between the members, substantially as described.

5. The combination of relatively movable members, spring arms connecting said members and a pin securing said arms to one member and constituting a stop for limiting relative movement between the members, substantially as described.

6. The combination of a driven member provided with diametrically opposed recesses opening inwardly, a driving member between said recesses, U-shaped springs having their ends extending into said recesses and engaging the sides thereof, and screws securing said springs intermediate their ends to said driving member, extending into said recesses between the arms of said springs and constituting stops, substantially as described.

This specification signed this 18th day of June, 1918.

JOHN P. CONSTABLE.

1190

Mar. 6, 1923. 1,447,913

A. TROWBRIDGE ET AL

RECORDING INDICATOR

Filed Oct. 5, 1920 8 sheets-sheet 1

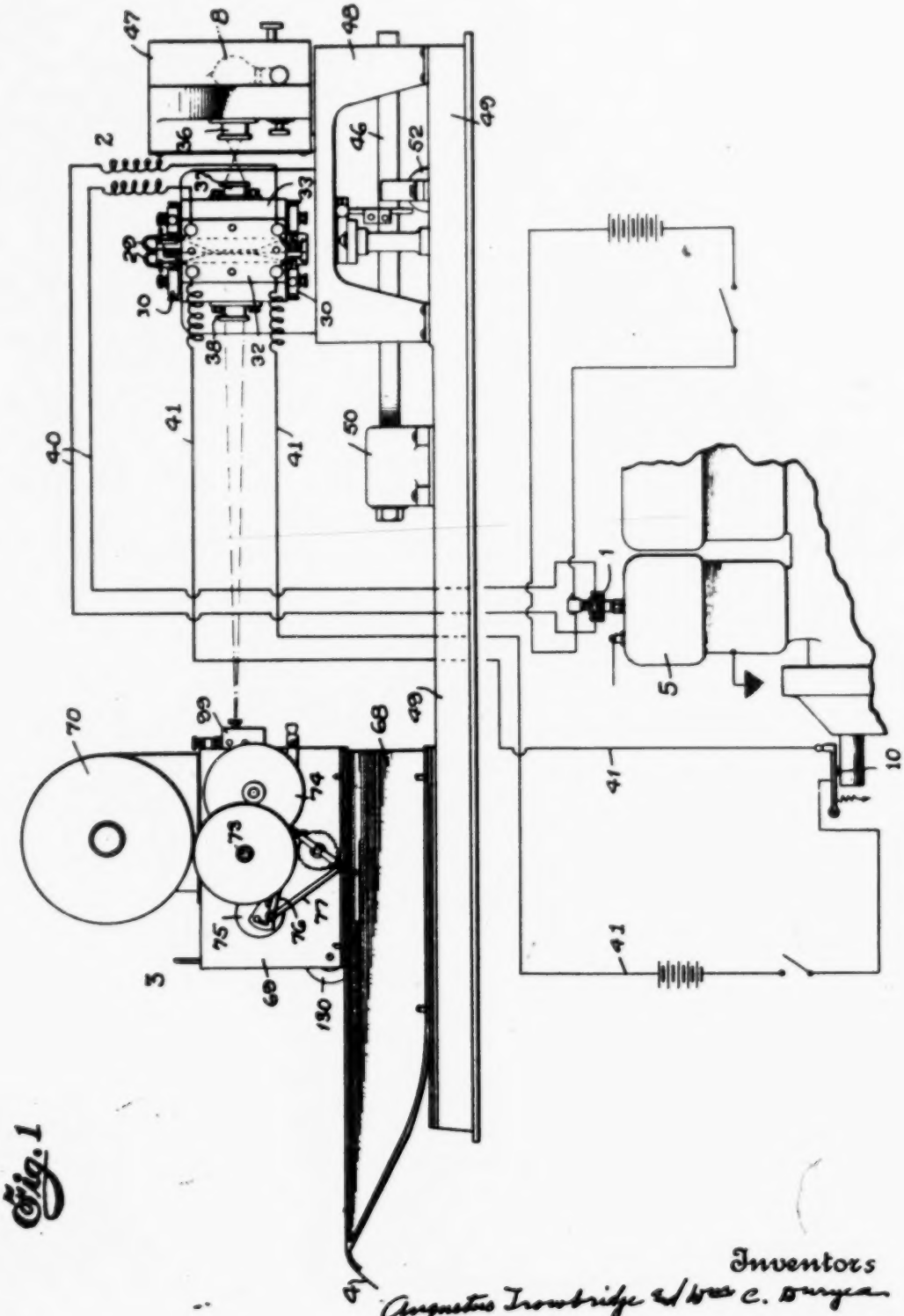

Fig. 1

Inventors
Augustus Trowbridge and Wm C. Burgess
By their Attorneys
Emery Varney Blair & Hoguet

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Mar. 6, 1923. 1,447,913

A. TROWBRIDGE ET AL

RECORDING INDICATOR

Filed Oct. 5, 1920 8 sheets-sheet 2

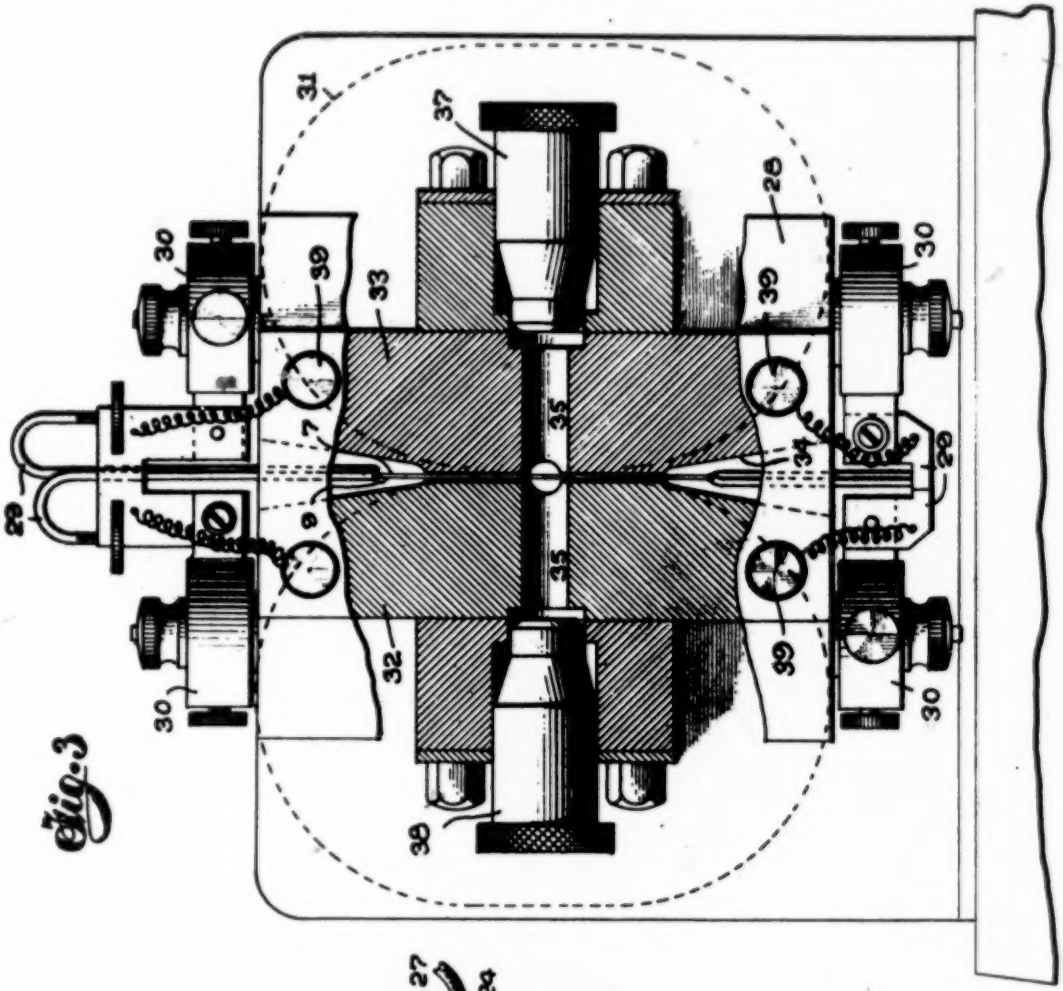

Fig. 3

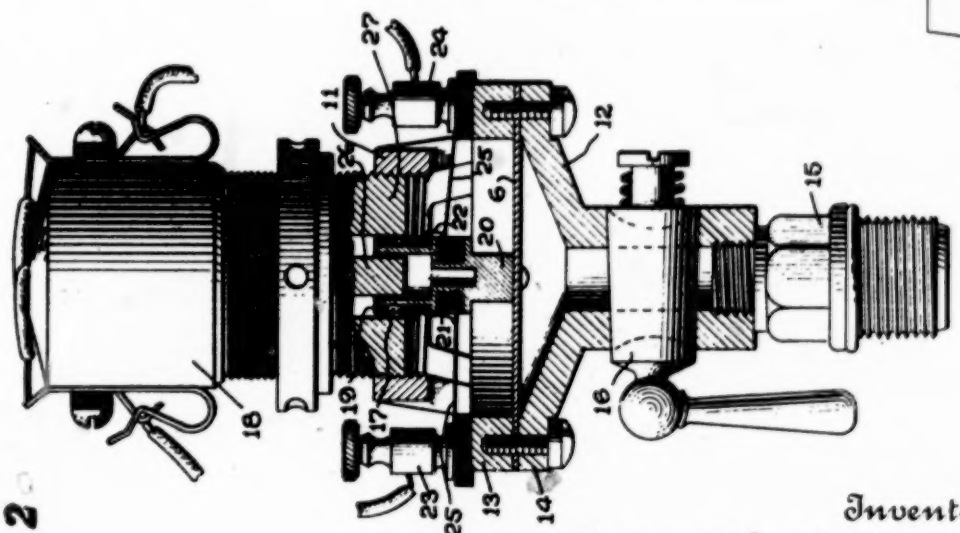

Fig. 2

Inventors
Augustus Trowbridge and Wm C. Durgin
By their Attorneys
Emery Varney Blair & Hoguet

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Mar. 6, 1923. 1,447,913

A. TROWBRIDGE ET AL

RECORDING INDICATOR

Filed Oct. 5, 1920 8 sheets-sheet 3

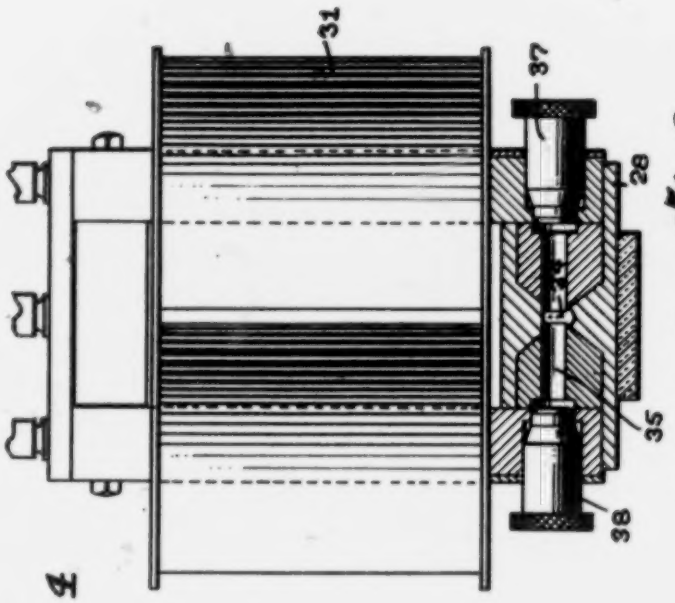

Fig. 4

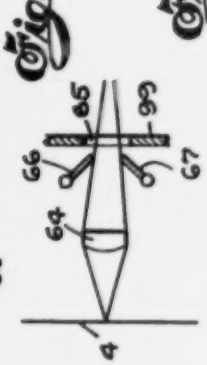

Fig. 8

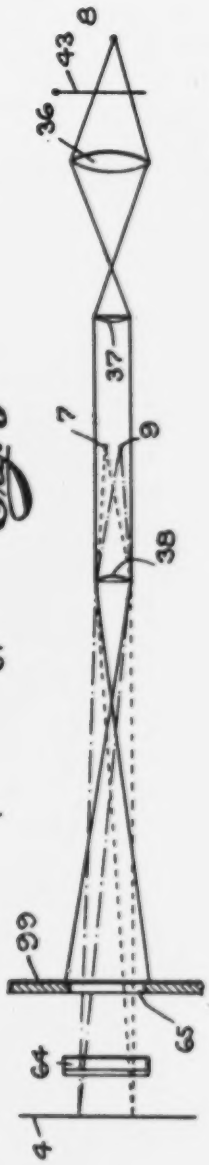

Fig. 9

Inventors
Augustus Trowbridge and Wm C. Burgess
By their Attorneys
Emery Vanney Blair & Hoguet

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Mar. 6, 1923. 1,447,913

A. TROWBRIDGE ET AL

RECORDING INDICATOR

Filed Oct. 5, 1920 8 sheets-sheet 4

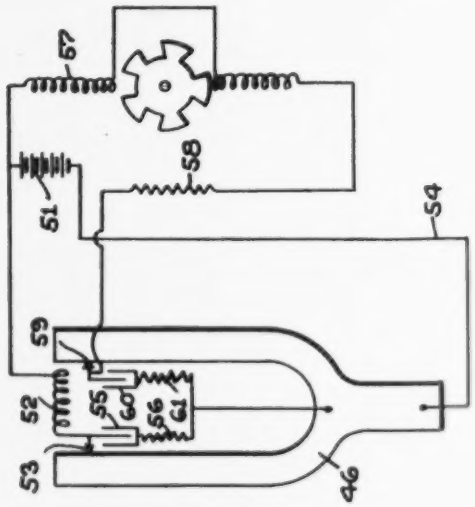

Fig. 7

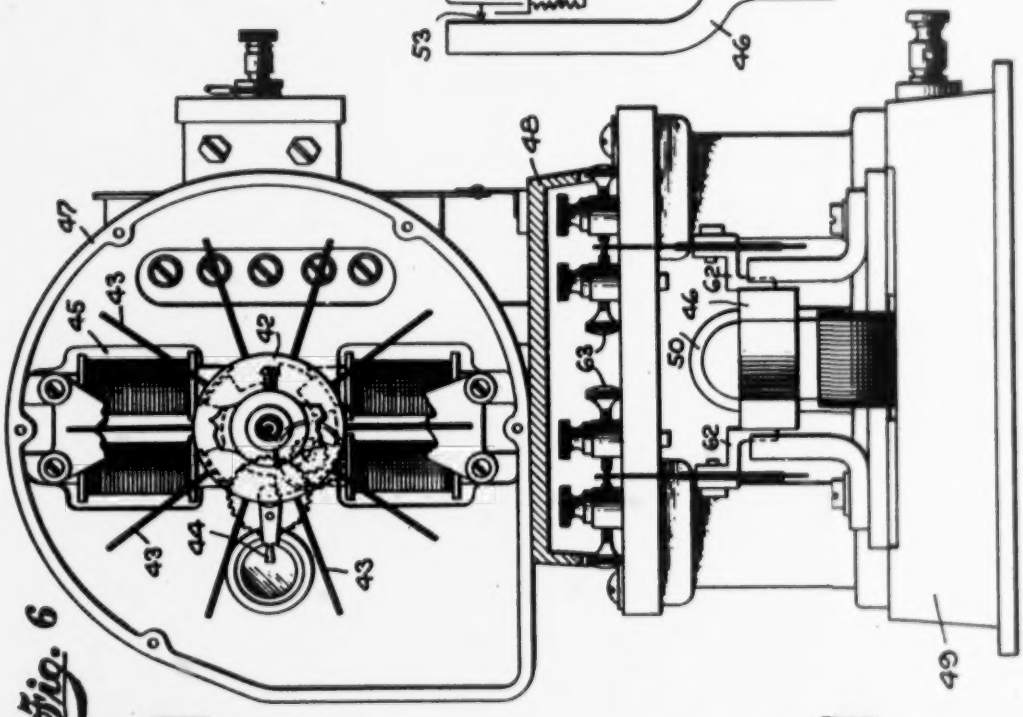

Fig. 6

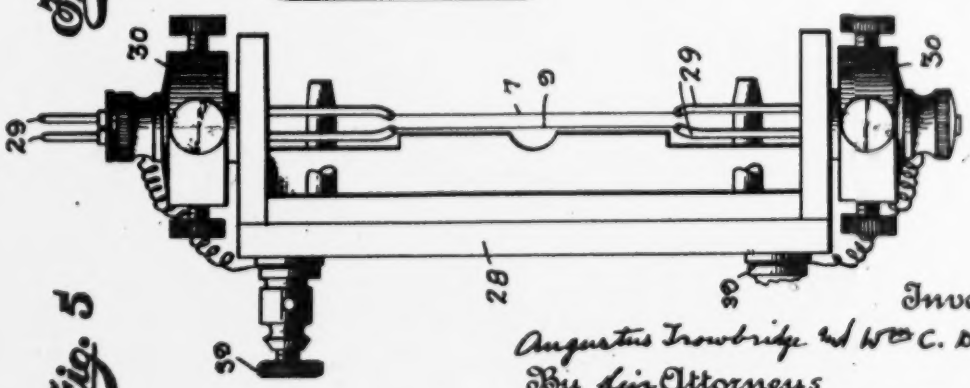

Fig. 5

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A. TROWBRIDGE ET AL

RECORDING INDICATOR

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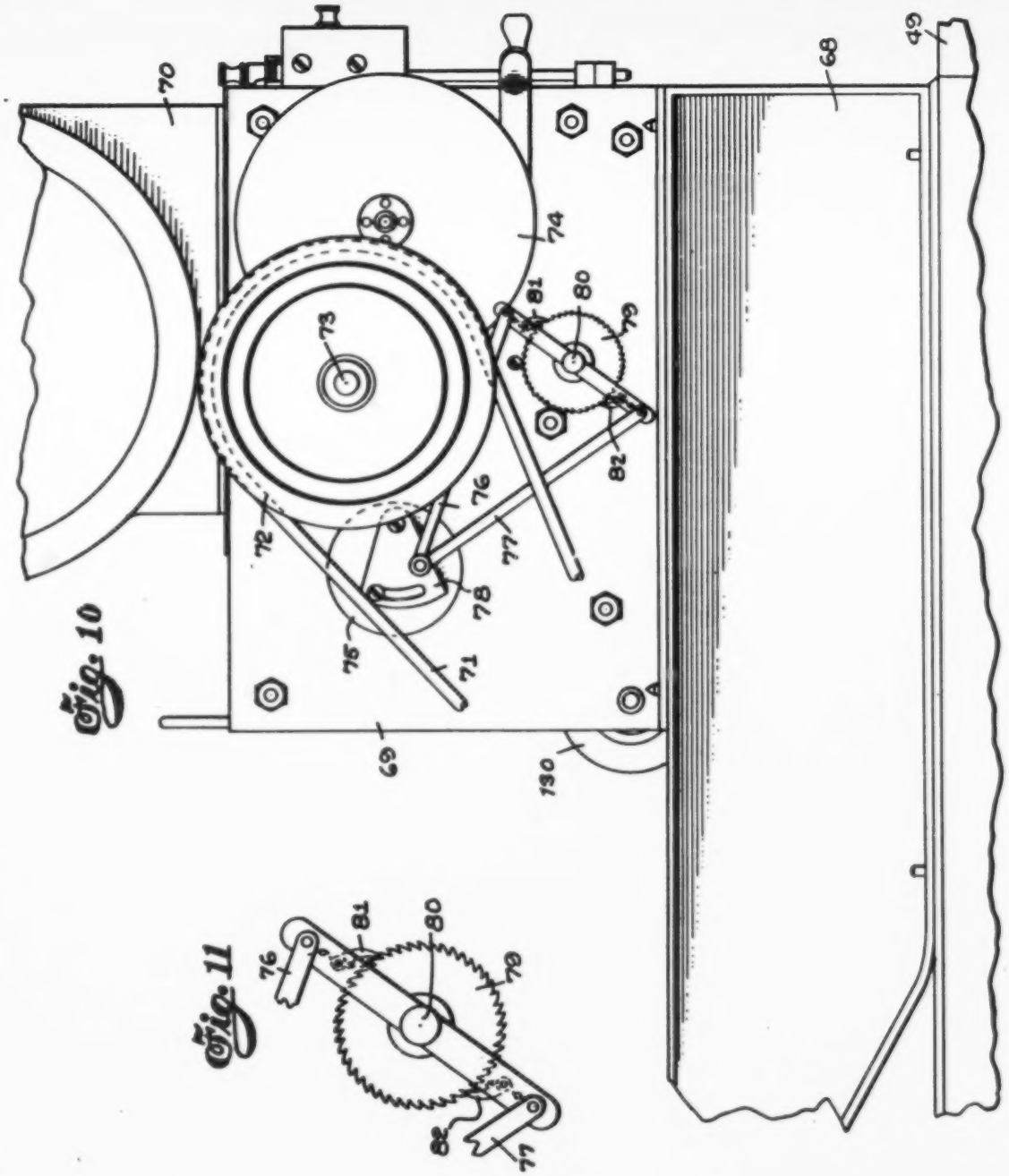

Fig. 10

Fig. 11

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A. TROWBRIDGE ET AL

RECORDING INDICATOR

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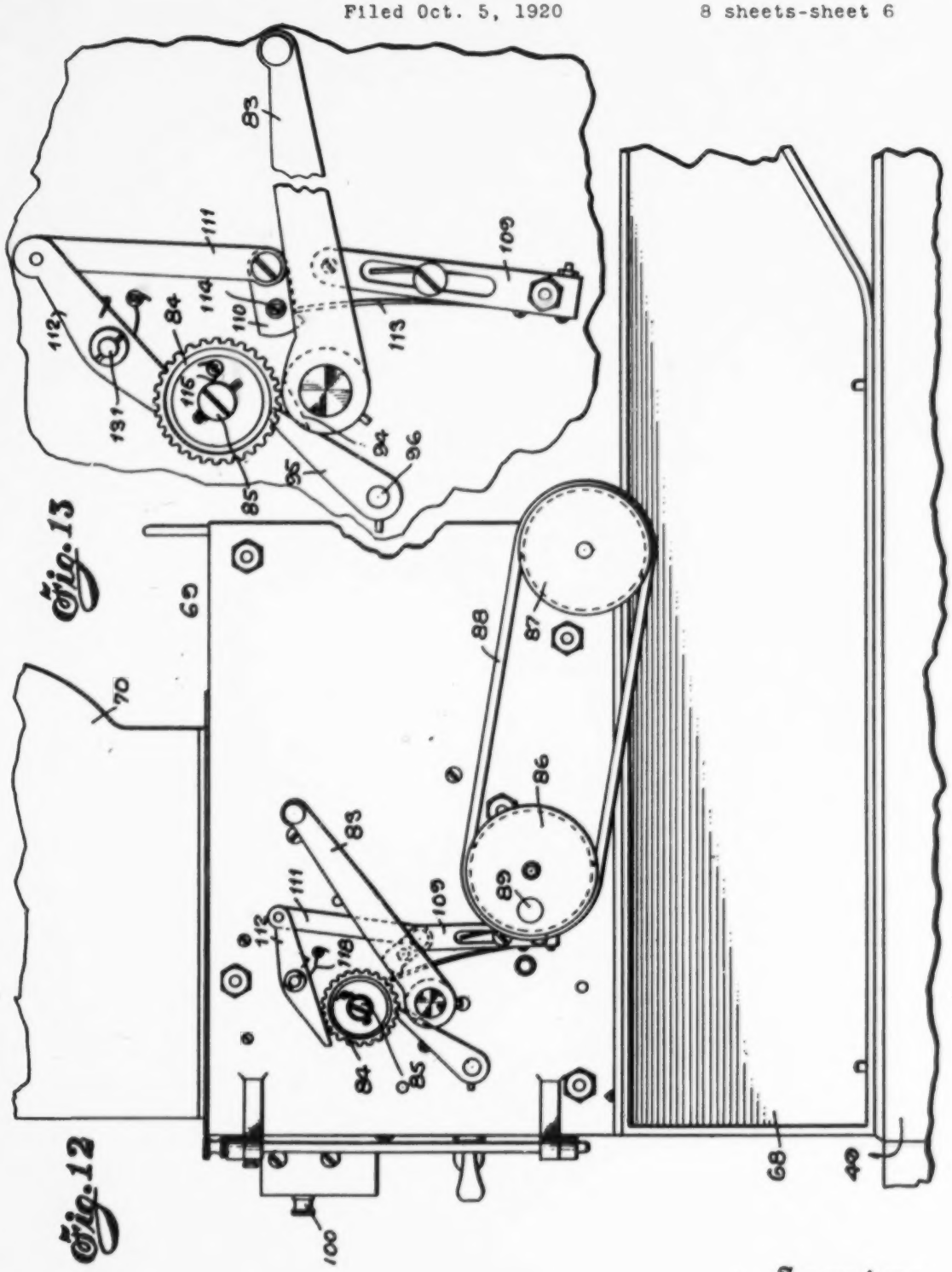

Fig. 13

Fig. 12

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RECORDING INDICATOR

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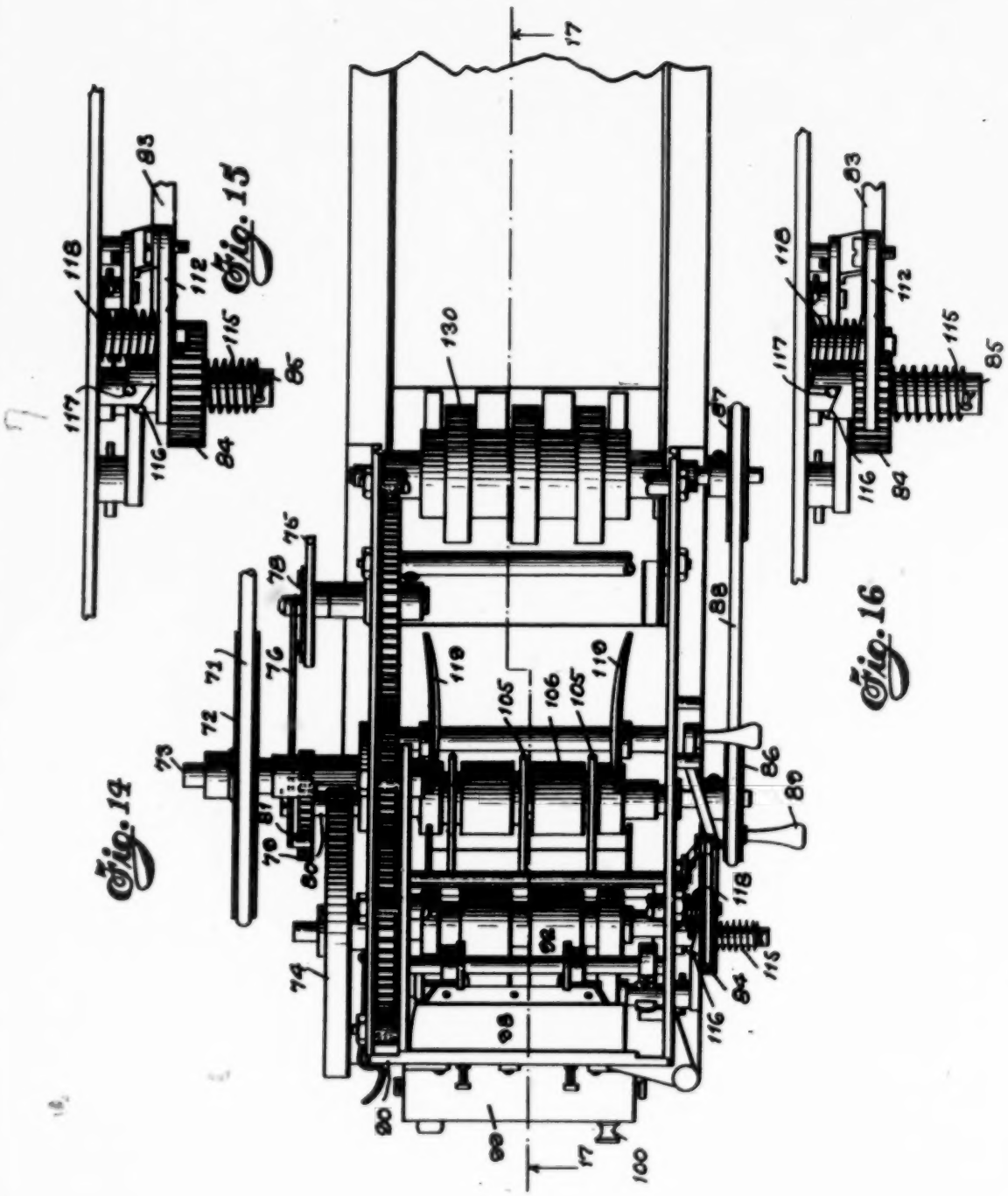

Fig. 15

Fig. 16

Fig. 14

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A. TROWBRIDGE ET AL

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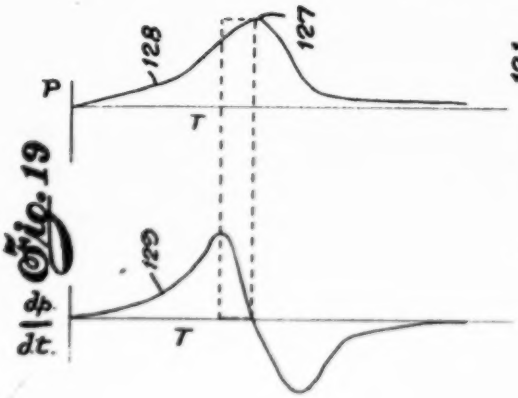
Fig. 19



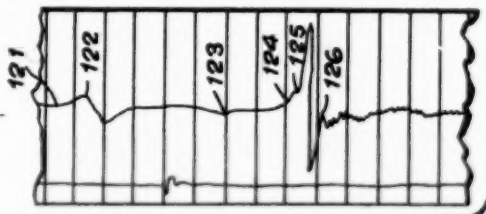


Fig. 17

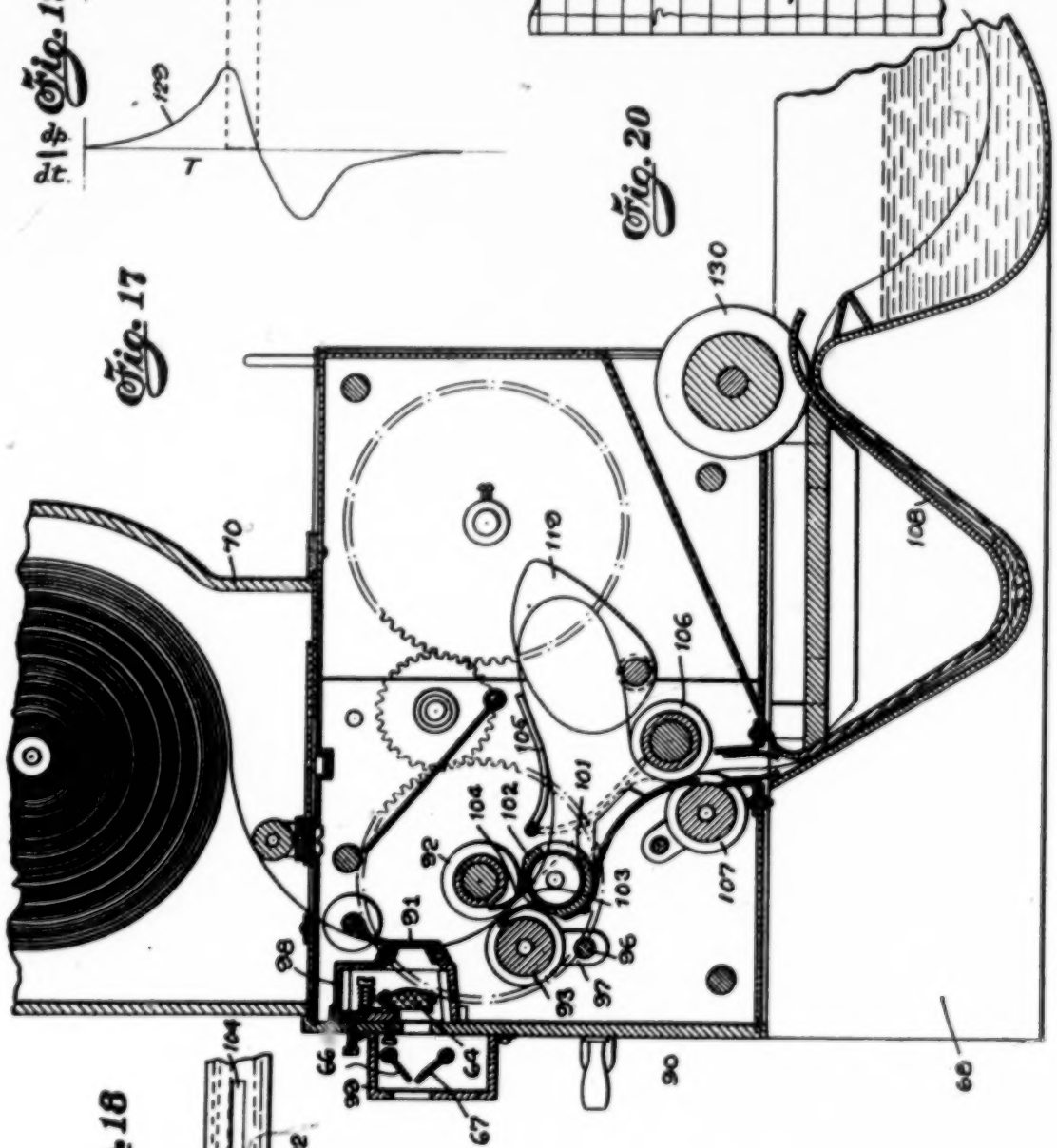


Fig. 18

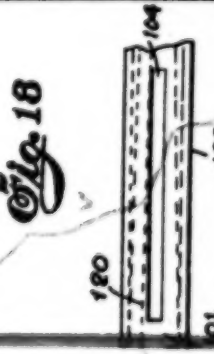


Fig. 20

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Patented Mar. 6, 1923. 1,447,913

UNITED STATES PATENT OFFICE.

AUGUSTUS TROWBRIDGE, OF WASHINGTON, DISTRICT OF COLUMBIA, AND WILLIAM C. DURYEA, OF PRINCETON, NEW JERSEY.

RECORDING INDICATOR.

Application filed October 5, 1920. Serial No. 414,742.

To all whom it may concern:

Be it known that we, AUGUSTUS TROWBRIDGE, a citizen of the United States of America, residing in the city of Washington, in the District of Columbia, and WILLIAM C. DURYEA, a citizen of the United States, and a resident of the city of Princeton, in the county of Mercer and State of New Jersey, have invented an Improvement in Recording Indicators, of which the following is a specification.

The invention relates to a precision instrument for observing and determining the obscure phenomena of working forces that are not readily appreciated by the unaided human senses.

One of the objects of this invention is to provide an apparatus for research or other work that will produce a visible. and if desired a permanent, record of the extent, duration and time of the variations in working forces or in the relative movement of bodies acted upon thereby. The particular apparatus selected is applicable in research or commercial work to determine variations in fluid pressures and the apparatus is shown as it would be arranged to investigate variations in pressures taking place in an internal combustion engine.

Another object of the invention is to provide a portable indicator that is capable of operation at very high rates of speed and that will accurately indicate all the variations of a working force.

A further object of the invention consists in providing an apparatus that will record and quickly produce a complete and permanent record of the movements of the indicator as it moves at high or low speeds. Other objects of this invention will be apparent in the following description.

A selected embodiment of the invention is shown in the accompanying drawings, wherein—

Figure 1 is a general view of the recording indicator as attached to an internal combustion engine;

Figure 2 is a view partially in section of

Figure 4 is a top plan view of Fig. 3 partially in section and on a slightly reduced scale.

Figure 5 is a side view of the supporting block.

Figure 6 is an end view of part of a galvanometer showing a spoked phonic wheel, a tuning fork, and the apparatus for operating the same;

Figure 7 is a diagrammatic illustration of the electrical connections between a motor driving the phonic wheel and the tuning fork;

Figures 8 and 9 are diagrammatic views of the beam of light as passing from its source to a film in the recorder.

Figure 10 is a view in elevation of the recorder or camera;

Figure 11 is a detailed view of one of the adjustable power transmitting parts of the recorder;

Figure 12 is a view in elevation of another side of the recorder;

Figure 13 is a detail of part of the apparatus in Fig. 12 shown in a second operating position;

Figure 14 is a top plan view of the recorder;

Figures 15 and 16 are views of part of the apparatus shown in Figs. 12 and 13 in different operating positions;

Figure 17 is a sectional view of the recorder;

Figure 18 is a front view of a cutter mounted in the recorder;

Figure 19 is a diagrammatic view of a curve recorded by this apparatus compared with a pressure curve; and

Figure 20 is a facsimile of the record produced by the recorder.

The features of the invention and the cooperation of the parts of the apparatus will be described in connection with the investigation of the gas pressures in a high speed internal combustion engine. The instrument selected for this application is provided with a recording means capable of making a com-

Mar. 6, 1923. 1,447,913

A. TROWBRIDGE ET AL

RECORDING INDICATOR

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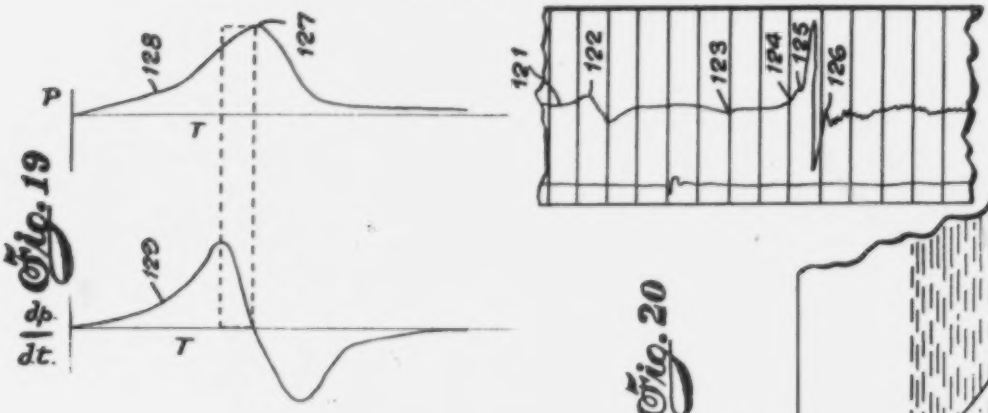

Fig. 19

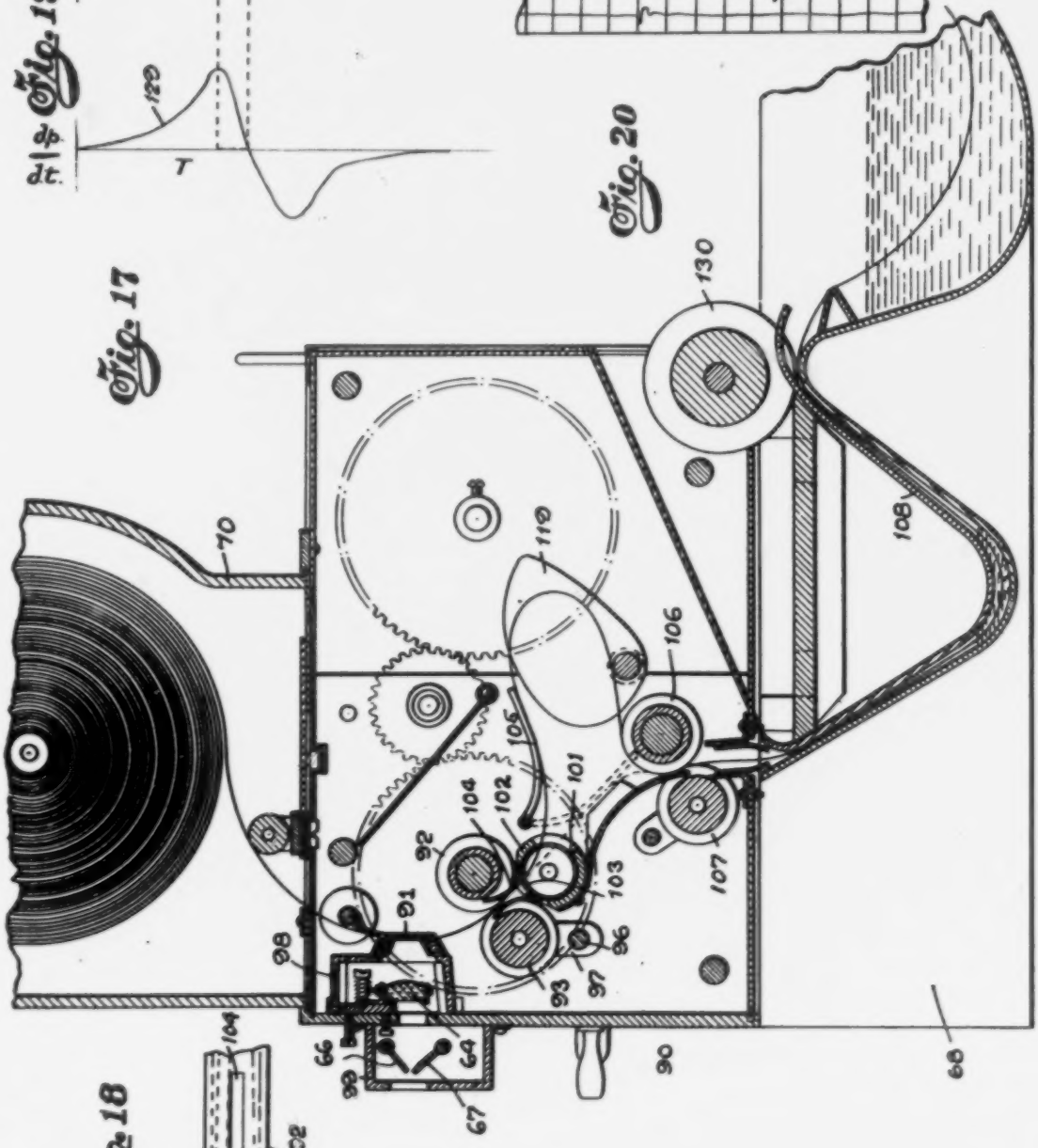

Fig. 20

Fig. 17

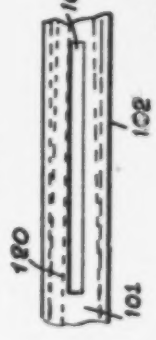

Fig. 18

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UNITED STATES PATENT OFFICE.

AUGUSTUS TROWBRIDGE, OF WASHINGTON, DISTRICT OF COLUMBIA, AND WILLIAM C. DURYEA, OF PRINCETON, NEW JERSEY.

RECORDING INDICATOR.

Application filed October 5, 1920. Serial No. 414,743.

To all whom it may concern:

Be it known that we, AUGUSTUS TROWBRIDGE, a citizen of the United States of America, residing in the city of Washington, in the District of Columbia, and WILLIAM C. DURYEA, a citizen of the United States, and a resident of the city of Princeton, in the county of Mercer and State of New Jersey, have invented an Improvement in Recording Indicators, of which the following is a specification.

The invention relates to a precision instrument for observing and determining the obscure phenomena of working forces that are not readily appreciated by the unaided human senses.

One of the objects of this invention is to provide an apparatus for research or other work that will produce a visible. and if desired a permanent, record of the extent, duration and time of the variations in working forces or in the relative movement of bodies acted upon thereby. The particular apparatus selected is applicable in research or commercial work to determine variations in fluid pressures and the apparatus is shown as it would be arranged to investigate variations in pressures taking place in an internal combustion engine.

Another object of the invention is to provide a portable indicator that is capable of operation at very high rates of speed and that will accurately indicate all the variations of a working force.

A further object of the invention consists in providing an apparatus that will record and quickly produce a complete and permanent record of the movements of the indicator as it moves at high or low speeds. Other objects of this invention will be apparent in the following description.

A selected embodiment of the invention is shown in the accompanying drawings, wherein—

Figure 1 is a general view of the recording indicator as attached to an internal combustion engine;

Figure 2 is a view partially in section of the indicating part of the recorder;

Figure 3 is a view partially in section of the end of a magnet and of a wire supporting block;

Figure 4 is a top plan view of Fig. 3 partially in section and on a slightly reduced scale.

Figure 5 is a side view of the supporting block.

Figure 6 is an end view of part of a galvanometer showing a spoked phonic wheel, a tuning fork, and the apparatus for operating the same;

Figure 7 is a diagrammatic illustration of the electrical connections between a motor driving the phonic wheel and the tuning fork;

Figures 8 and 9 are diagrammatic views of the beam of light as passing from its source to a film in the recorder.

Figure 10 is a view in elevation of the recorder or camera;

Figure 11 is a detailed view of one of the adjustable power transmitting parts of the recorder;

Figure 12 is a view in elevation of another side of the recorder;

Figure 13 is a detail of part of the apparatus in Fig. 12 shown in a second operating position;

Figure 14 is a top plan view of the recorder;

Figures 15 and 16 are views of part of the apparatus shown in Figs. 12 and 13 in different operating positions;

Figure 17 is a sectional view of the recorder;

Figure 18 is a front view of a cutter mounted in the recorder;

Figure 19 is a diagrammatic view of a curve recorded by this apparatus compared with a pressure curve; and

Figure 20 is a facsimile of the record produced by the recorder.

The features of the invention and the cooperation of the parts of the apparatus will be described in connection with the investigation of the gas pressures in a high speed internal combustion engine. The instrument selected for this application is provided with a recording means capable of making a complete and permanent record of the operations of the engine when rotated at various speeds and especially at its maximum speed. The apparatus may also be used to investigate relative movements of mechanical ele-

ments subjected to variable working forces. The instrument will be hereinafter referred to as an indicating recorder.

Referring to the drawings and particularly to Fig. 1, the apparatus is illustrated as comprising an indicator 1 adapted to be attached to a moving object or in contact with fluids under pressure, a galvanometer 2 electrically connected to the indicator, and a recording apparatus, as camera 3, for recording on a tape, such as a sensitized paper or film 4, the movements of parts of the galvanometer. For purposes of brevity and convenience, the movements of the diaphragm by pressure will be understood as also being capable of movement by means of a moving mechanical element and the recording sensitized paper will be hereinafter referred to as the film and it is intended to include under this term all sensitized tapes which pass through the camera to receive certain indications.

The application of the recording indicator to an internal combustion engine is shown in Fig. 1 where the indicator 1 is positioned in a suitable pet cock or spark plug opening in a cylinder 5. This indicator is preferably provided with a moving member such as a diaphragm 6 adapted to be suitably mounted so that it may vibrate in its forced period of vibration. An electrical apparatus is associated with the diaphragm and is operated by the movement thereof to generate electrical energy which is conducted by suitable means to a small wire 7 (Fig. 3) positioned in a magnetic field. The galvanometer part of the apparatus consists of means for holding the vibrating wire, a suitable light source such as lamp 8 for illuminating the wire, and lenses for focusing the beam of light on the film 4 (Fig. 9) carried in the camera. The shadow formed in the beam of light by the wire will be projected upon the film and the movements of the wire by reason of electrical energy passing therethrough when the wire is under the influence of electromagnetic lines of force will cause the wire to vibrate and, therefore, the shadow to move across the film. A second vibrating wire 9 is mounted by the side of the first one and is moved at intervals by electrical energy supplied from a suitable source, such as a battery, when the closing of a switch operated by the nub 10 suitably mounted on the crank shaft of the engine completes the circuit. The record on the film of the second vibrating wire indicates the position of the crank shaft at the time events occur in the cycle of operation of the engine.

Describing the apparatus more in detail, lower parts 11 and 12 respectively which are provided with flanges 13 and 14 for firmly holding the diaphragm. This type of construction of the indicator provides for the substitution of diaphragms having greater or less flexibility thus permitting flexibility of use of the recording indicator. An attachment 15 is affixed to the lower part of the indicator for fastening the indicator in a spark plug or pet cock opening. The lower part of the frame is provided with a valve 16 for opening the passageway between the diaphragm and the engine cylinder.

The electrical apparatus carried in the indicator for developing electromotive force preferably consists of a coil 17 moved by the diaphragm, and a magnet 18 having its core in proximity to the coil so that movements of the diaphragm will cause the coil to cut magnetic lines of force. The coil is preferably mounted in an annular depression in an insulator 19 carried on a standard 20 which is firmly attached to the diaphragm. This coil is provided with lead wires 21 and 22 extending therefrom to binding posts 23 and 24 mounted on the flange 13 and suitable connections attached to these posts are provided for the transmission of the electrical energy to the vibrating wire 7. The lead wires 21 and 22 are preferably supported on very thin sheets of material 25 of high flexibility which will not have a dampening effect on the diaphragm. The combination of the coil, insulator, and the standard will, for purposes of convenience and brevity be hereinafter referred to as a bobbin. The upper part of the indicator frame is provided with screw threads which permit of the vertical adjustment of the magnet so that the coil 17 may pass through a magnetic field of greater or less density. Preferably, the ends 26 and 27 of the magnet are annular and concentric with one another so that the inner end 26, which is preferably the north pole, will be received inside the bobbin and within the coil, and the outer end 27 being of bell shape will surround the bobbin. The magnet may be a permanent magnet or may be separately excited, as illustrated in the drawings where it is in circuit with a source of power and a manually operated switch.

The galvanometer part of the apparatus is illustrated in detail in Figs. 3 to 7 inclusive. Referring now to these figures, the vibrating wires 7 and 9 are preferably of very small size in order to reduce their inertia to the smallest degree, so a clear cut indication of their movements may be obtained on the film. Preferably the wires are

permit the wires to be placed under the desired tension. The block 28 is suitably held on the core of a magnet 31 which constitutes part of the galvanometer. One end of the core of this magnet is shown in section in Fig. 3 and consists of poles 32 and 33 which form a passageway 34 between them into which the vibrating wires are moved as the block 28 is positioned on the core (see Figs. 3 and 4). The poles of the magnet are provided with longitudinal openings 35 to permit a beam of light to pass through lenses 36, 37 and 38 to illuminate the vibrating wires. The block is also provided with suitable binding posts 39 for connecting the lead wires 40 from the bobbin, and lead wires 41 from the make and break switch operated by the engine crank shaft.

A suitable means for interrupting the beam of light at definite time intervals is provided by a rotating or phonic wheel 42 having spokes 43 which pass in front of the light to interrupt the same thereby casting shadows which extend completely across the film. Preferably the shadows as recorded on the film by the spokes denote a time interval of one one-hundredth of a second, but this may be varied by changing the speed of the wheel. There is geared to the shaft carrying the spoked wheel a protruding member 44 which partially intercepts the beam of light and forms an indication on the film of the passing of a larger interval of time than is indicated by the spoke shadows.

The spoked wheel is preferably rotated by a suitable constant speed motor 45 operated in synchronism with a tuning fork 46. Referring particularly to Fig. 6, the phonic wheel driving motor 45 is held in a frame 47 which in turn is supported on platform 48 mounted on base 49 of the apparatus, and the tuning fork 46 is firmly held in a yoke 50 attached to the base while the tines of the fork extend between the supporting legs of the platform, as will be noted in Fig. 1. The operation of the tuning fork and the motor will be more readily appreciated by reference to Fig. 7, which is a diagrammatic view of the electrical connections. Electrical power is derived from a suitable source, such as battery 51 and current therefrom passes through a coil 52 mounted between the tines of the tuning fork and through make and break contact 53, through the tuning fork, back to the other side of the battery through lead wire 54. A suitable condenser 55 and resistance 56 are provided to eliminate sparking when contact is broken at contact 53. The function of the coil 52 is to pull the tines of the other connection from the battery leads through the motor field 57, through a resistance 58, to a second make and break contact 59, to one of the tines, and from there through lead wire 54, back to the battery. This second make and break contact is also provided with a condenser 60 and a resistance 61. Both make and break contacts are mounted on posts 62 and are provided with suitable adjustable shafts 63 so that the position of the contacting points may be varied. The hereinabove described phonic wheel provides one means of marking time intervals on the film and it is to be understood that others may be employed.

The beam of light having the shadows therein of the vibrating wires and of the spokes of the phonic wheel, passes from lens 38 in the galvanometer to the reducing or cylindrical lens 64 in the recorder or camera, and on to the film where the movements of the vibrating wires are recorded in relation to the lapses of time and in respect to known conditions of the operating machine.

For purposes of clarity in showing the path of the light, reference is made to Figs. 8 and 9. Referring particularly to Fig. 9, which is a diagrammatic view of the lenses and the beam of light when looking down upon the apparatus, the source of light or lamp 8 is illustrated at the right-hand end of the figure, and the suitable lenses are shown in diagrammatic form. A spoke of the phonic wheel is shown in position between the lamp 8 and lens 36, and the vibrating wires 7 and 9 are shown as located between lenses 37 and 38. The cylindrical or reducing lens is shown at the left-hand end of the figure positioned in front of the sensitized film. The shadows cast by the vibrating wires are shown in dotted lines and the paths of these shadows are obtained by considering the wires as luminous bodies sending light to the sensitized film through lenses 38 and 64. The main function of the cylindrical or reducing lens 64 is illustrated in diagrammatic form in Fig. 8 wherein the beam of light with the shadows formed therein enters the recorder or camera through aperture 65 and passes beyond oscillating plates 66 and 67 to the lens 64 which converges the same to a point on the sensitized film 4.

Referring now to the recording or camera part of the recording indicator, a suitable apparatus for making a permanent record of the movements of the vibrating wires will be hereinafter described, but this recorder may be used for other purposes and in connection with other apparatus. For

ments subjected to variable working forces. The instrument will be hereinafter referred to as an indicating recorder.

Referring to the drawings and particularly to Fig. 1, the apparatus is illustrated as comprising an indicator 1 adapted to be attached to a moving object or in contact with fluids under pressure, a galvanometer 2 electrically connected to the indicator, and a recording apparatus, as camera 3, for recording on a tape, such as a sensitized paper or film 4, the movements of parts of the galvanometer. For purposes of brevity and convenience, the movements of the diaphragm by pressure will be understood as also being capable of movement by means of a moving mechanical element and the recording sensitized paper will be hereinafter referred to as the film and it is intended to include under this term all sensitized tapes which pass through the camera to receive certain indications.

The application of the recording indicator to an internal combustion engine is shown in Fig. 1 where the indicator 1 is positioned in a suitable pet cock or spark plug opening in a cylinder 5. This indicator is preferably provided with a moving member such as a diaphragm 6 adapted to be suitably mounted so that it may vibrate in its forced period of vibration. An electrical apparatus is associated with the diaphragm and is operated by the movement thereof to generate electrical energy which is conducted by suitable means to a small wire 7 (Fig. 3) positioned in a magnetic field. The galvanometer part of the apparatus consists of means for holding the vibrating wire, a suitable light source such as lamp 8 for illuminating the wire, and lenses for focusing the beam of light on the film 4 (Fig. 9) carried in the camera. The shadow formed in the beam of light by the wire will be projected upon the film and the movements of the wire by reason of electrical energy passing therethrough when the wire is under the influence of electromagnetic lines of force will cause the wire to vibrate and, therefore, the shadow to move across the film. A second vibrating wire 9 is mounted by the side of the first one and is moved at intervals by electrical energy supplied from a suitable source, such as a battery, when the closing of a switch operated by the nub 10 suitably mounted on the crank shaft of the engine completes the circuit. The record on the film of the second vibrating wire indicates the position of the crank shaft at the time events occur in the cycle of operation of the engine.

Describing the apparatus more in detail, reference is first made to Fig. 2 where the indicator is illustrated on a larger scale and partly in section. This indicator preferably consists of a frame having upper and lower parts 11 and 12 respectively which are provided with flanges 13 and 14 for firmly holding the diaphragm. This type of construction of the indicator provides for the substitution of diaphragms having greater or less flexibility thus permitting flexibility of use of the recording indicator. An attachment 15 is affixed to the lower part of the indicator for fastening the indicator in a spark plug or pet cock opening. The lower part of the frame is provided with a valve 16 for opening the passageway between the diaphragm and the engine cylinder.

The electrical apparatus carried in the indicator for developing electromotive force preferably consists of a coil 17 moved by the diaphragm, and a magnet 18 having its core in proximity to the coil so that movements of the diaphragm will cause the coil to cut magnetic lines of force. The coil is preferably mounted in an annular depression in an insulator 19 carried on a standard 20 which is firmly attached to the diaphragm. This coil is provided with lead wires 21 and 22 extending therefrom to binding posts 23 and 24 mounted on the flange 13 and suitable connections attached to these posts are provided for the transmission of the electrical energy to the vibrating wire 7. The lead wires 21 and 22 are preferably supported on very thin sheets of material 25 of high flexibility which will not have a dampening effect on the diaphragm. The combination of the coil, insulator, and the standard will, for purposes of convenience and brevity be hereinafter referred to as a bobbin. The upper part of the indicator frame is provided with screw threads which permit of the vertical adjustment of the magnet so that the coil 17 may pass through a magnetic field of greater or less density. Preferably, the ends 26 and 27 of the magnet are annular and concentric with one another so that the inner end 26, which is preferably the north pole, will be received inside the bobbin and within the coil, and the outer end 27 being of bell shape will surround the bobbin. The magnet may be a permanent magnet or may be separately excited, as illustrated in the drawings where it is in circuit with a source of power and a manually operated switch.

The galvanometer part of the apparatus is illustrated in detail in Figs. 3 to 7 inclusive. Referring now to these figures, the vibrating wires 7 and 9 are preferably of very small size in order to reduce their inertia to the smallest degree, so a clear cut indication of their movements may be obtained on the film. Preferably the wires are adjustably supported on a suitable block 28 of U-shape (illustrated in Figs. 3 and 5) by means of supporting pieces 29 held in universally adjusted standards 30 which also

permit the wires to be placed under the desired tension. The block 28 is suitably held on the core of a magnet 31 which constitutes part of the galvanometer. One end of the core of this magnet is shown in section in Fig. 3 and consists of poles 32 and 33 which form a passageway 34 between them into which the vibrating wires are moved as the block 28 is positioned on the core (see Figs. 3 and 4). The poles of the magnet are provided with longitudinal openings 35 to permit a beam of light to pass through lenses 36, 37 and 38 to illuminate the vibrating wires. The block is also provided with suitable binding posts 39 for connecting the lead wires 40 from the bobbin, and lead wires 41 from the make and break switch operated by the engine crank shaft.

A suitable means for interrupting the beam of light at definite time intervals is provided by a rotating or phonic wheel 42 having spokes 43 which pass in front of the light to interrupt the same thereby casting shadows which extend completely across the film. Preferably the shadows as recorded on the film by the spokes denote a time interval of one one-hundredth of a second, but this may be varied by changing the speed of the wheel. There is geared to the shaft carrying the spoked wheel a protruding member 44 which partially intercepts the beam of light and forms an indication on the film of the passing of a larger interval of time than is indicated by the spoke shadows.

The spoked wheel is preferably rotated by a suitable constant speed motor 45 operated in synchronism with a tuning fork 46. Referring particularly to Fig. 6, the phonic wheel driving motor 45 is held in a frame 47 which in turn is supported on platform 48 mounted on base 49 of the apparatus, and the tuning fork 46 is firmly held in a yoke 50 attached to the base while the tines of the fork extend between the supporting legs of the platform, as will be noted in Fig. 1. The operation of the tuning fork and the motor will be more readily appreciated by reference to Fig. 7, which is a diagrammatic view of the electrical connections. Electrical power is derived from a suitable source, such as battery 51 and current therefrom passes through a coil 52 mounted between the tines of the tuning fork and through make and break contact 53, through the tuning fork, back to the other side of the battery through lead wire 54. A suitable condenser 55 and resistance 56 are provided to eliminate sparking when contact is broken at contact 53. The function of the coil 52 is to pull the tines of the fork together in a well-known manner and their vibration will throw them so that the make and break contact 53 will open the circuit when the tines move outward. The other connection from the battery leads through the motor field 57, through a resistance 58, to a second make and break contact 59, to one of the tines, and from there through lead wire 54, back to the battery. This second make and break contact is also provided with a condenser 60 and a resistance 61. Both make and break contacts are mounted on posts 62 and are provided with suitable adjustable shafts 63 so that the position of the contacting points may be varied. The hereinabove described phonic wheel provides one means of marking time intervals on the film and it is to be understood that others may be employed.

The beam of light having the shadows therein of the vibrating wires and of the spokes of the phonic wheel, passes from lens 38 in the galvanometer to the reducing or cylindrical lens 64 in the recorder or camera, and on to the film where the movements of the vibrating wires are recorded in relation to the lapses of time and in respect to known conditions of the operating machine.

For purposes of clarity in showing the path of the light, reference is made to Figs. 8 and 9. Referring particularly to Fig. 9, which is a diagrammatic view of the lenses and the beam of light when looking down upon the apparatus, the source of light or lamp 8 is illustrated at the right-hand end of the figure, and the suitable lenses are shown in diagrammatic form. A spoke of the phonic wheel is shown in position between the lamp 8 and lens 36, and the vibrating wires 7 and 9 are shown as located between lenses 37 and 38. The cylindrical or reducing lens is shown at the left-hand end of the figure positioned in front of the sensitized film. The shadows cast by the vibrating wires are shown in dotted lines and the paths of these shadows are obtained by considering the wires as luminous bodies sending light to the sensitized film through lenses 38 and 64. The main function of the cylindrical or reducing lens 64 is illustrated in diagrammatic form in Fig. 8 wherein the beam of light with the shadows formed therein enters the recorder or camera through aperture 65 and passes beyond oscillating plates 66 and 67 to the lens 64 which converges the same to a point on the sensitized film 4.

Referring now to the recording or camera part of the recording indicator, a suitable apparatus for making a permanent record of the movements of the vibrating wires will be hereinafter described, but this recorder may be used for other purposes and in connection with other apparatus. For purposes of brevity the recorder will be hereinafter referred to as a camera.

Referring to Fig. 10, the camera preferably consists of a tank 68 mounted on the

base 49, a light-proof container 69 for carrying the operating parts of the apparatus, and a film magazine 70, suitably positioned on top of the container. Power is supplied to the apparatus by means of a motor (not shown) through a belt 71 operating on pulley 72 for driving a main shaft 73. A fly wheel 74 operated by the main shaft through a series of gears maintains the moving parts of the apparatus at uniform speeds. Referring also to Fig. 10, there is shown a suitable off-center arrangement for transmitting power at a reduced speed to a set of rollers located in the lower part of the container and preferably consists of a rotating blank wheel 75 driven by gears operated from the main shaft, levers 76 and 77 adjustably positioned off center on the blank by means of a movable quadrant 78, and a toothed wheel 79 mounted on a shaft 80 carrying one of the rollers driven by the levers 76 and 77 operating through engaging pawls 81 and 82, as shown in detail in Fig. 11. The two levers carrying the pawls 81 and 82 are mounted on the shaft 80 and are free to be oscillated about that shaft, thus the movements of the levers 76 and 77 are independent and the two levers that carry the pawls are likewise independent and separately movable. From the description of the foregoing apparatus it will be readily seen that the speed of the roller may be increased or decreased by moving the pivoted ends of the levers away from or toward the center of the blank wheel 75.

Referring to Fig. 12, the apparatus mounted on the opposite outside surface of the container 69 consists of a main operating handle 83 for throwing the operating parts of the camera into and out of operation, a wheel 84 slidably carried on the shaft 85 which also carries one of the driving rollers for moving the film, and pivoted levers which operate with the movement of the operating handle to throw certain parts of the apparatus into operating position. Suitable pulleys 86 and 87 connected by a belt 88 transmit power to a guiding roller 130 (see Fig. 17) which assists in moving the film through suitable developer and fixing baths. A handle 89 is provided to manually rotate the guiding roller when desired.

Referring particularly to Figs. 14 to 17 inclusive, a description of the operation of the camera will be made while following the path of the film through the camera. A door 90 pivoted on the container 69 is opened and the film drawn from the magazine down across an oscillating spring biased guide 91 and into contact with a driving roller 92. apparatus for moving this second driving roller preferably consists of a suitable cam 94 (see Fig. 13) mounted on the hub of the operating handle for moving a lever 95 backward to rotate shaft 96 carrying lever 97 upon which the roller is mounted. After the film is properly threaded between the driving rollers, the door is closed and a guard 98 surrounding the lens 64 mounted in the door moves its velvet covered edges into contact with the film and presses the same against the guide 91 thus making the enclosure between the door and the interior of the container light-proof. A second guard 99 held on the front of the door carries the oscillating plates 66 and 67 which are movable by thumb screw 100 (see Fig. 14) to increase or decrease the width of the light beam admitted to the lens 64. Preferably these plates are adjusted so that the width of the opening is less than the shadow cast by the spokes of the phonic wheel.

The movement of the operating handle to its "up" position oscillates an apertured cylinder 101 mounted in a cylindrical tapering seat in a second apertured cylinder 102 (see Fig. 17) so that apertures 103 and 104 register and permit the film as moved by the driving rollers to pass therethrough into contact with a guiding fork 105 shown in its lower or "down" position in dotted lines. This fork guides the end of the film from the driving rollers to a second set of rollers 106 and 107, and is maintained in its lower position until the film is caught by these lower rollers, when it is automatically thrown to its "up" position, represented in full lines, and the film is then allowed to double back on itself, as shown in full lines, and to be stored within the container until the lower rollers draw the same forward and move it through developer and fixing liquids maintained in the tank. Proper guiding means such as a V-shaped guide 108 is held in the tank 68 to guide the film through the developing fluids. From the above description it will be noted that the camera exposes the film at one rate of speed and develops it at another rate, this last rate of speed being variable by means of the apparatus above described.

Referring now to Figs. 12, 13, 15 and 16, the operation of the guiding fork and its mechanism will be set forth. Preferably this guiding fork is thrown to its "down" position by the upward movement of the operating handle, and is automatically moved to its "up" position after the power has been applied to the camera for a definite period of time. The mechanism required

to the lever rotates the second lever 110 on its shaft 114 and pulls down lever 111 which, being attached to the end of the fourth lever 112, rotates the same about its pivot 131, and moves its free end upward and out of contact with the side of wheel 84. The fork is mounted on shaft 114. The wheel 84 is mounted on shaft 85 carrying one of the driving rollers and is biased by a compression spring 115 to a position near the side of the container. This wheel has on the end of its hub a cam 116 which engages a pin 117 carried in the shaft. The end of the fourth lever engages the top or circumferential surface of the wheel when the fork has been moved to its "down" position, and the levers are in positions shown in Figs. 12 and 16. When the power is applied, pin 117 moves in contact with the cam forcing the wheel outward and compressing spring 115 until the pin reaches the end of the cam at that instant the fourth lever has moved out of contact with the circumferential surface of wheel 84 and is thrown by spring 118 against the hub of the wheel and into contact with the side thereof to maintain the same in its outer position. The spring 118 mounted on the pivot of the fourth lever is of sufficient strength to throw the other attached levers and consequently the fork is rotated to its "up" position, as shown in full lines in Fig. 17. The positions of the levers after being moved are shown in Figs. 13 and 15. When the fork is in "up" position the film is permitted to double back on itself between guides 119 and is later drawn between the lower rollers and moved into the developing fluids.

When the operating handle is moved to its "down" position to stop the movement of the paper by moving the second driving roller out of contact with the first one, a sharp edge 120 formed at an angle to the center line of the apertured cylinder 101 (see Fig. 18) is progressively moved against the other apertured cylinder 102 to cut the film. The remaining parts of the apparatus continue to operate until the lower rollers have moved the film held in storage through the developer and fixing baths and the guiding rollers 130 has moved the film from the developer solution.

Referring now to Fig. 20, which represents the permanent film as it issues from the camera, the movements of the diaphragm of the indicator are shown as recorded on the film. The lines extending across the film represent the shadows cast by the spokes of the phonic wheel and, as hereinbefore stated, indicate time intervals of one one-hundredth of a second. The engine this curve represents the actual pressure variations in the cylinder during the cycle of operation of the engine. The portion of the curve between the points 121 and 122 indicates the pressure variation in the cylinder during a compression stroke of the engine, and the expansion thereof without the firing or burning of the gases is shown next to the right. The induction or suction stroke of the engine is illustrated at point 123 and a second compression stroke is illustrated at 124 and the firing of the gases takes place at 125 which is just prior to the completion of the upward movement of the piston. The pressure variation during the burning of the gases in the cylinder is represented by the wide movement in the curve in this figure and the operation of the exhaust valve is shown as commencing at the point 126.

The lower curve illustrates the movements of the second vibrating wire 9 and shows the passing of current through that wire by means of the operation of the switch associated with the crank shaft in the engine. Since the position of nub 10 on the crank shaft to close this switch is known with respect to the position of the piston in cylinder 5, the time of the firing of the gases and the movements of the inlet and exhaust valves in respect to the engine shaft are readily determined. The distance of any part of the curve from its normal indicates the variation of the intensity of the gas pressures in the cylinders. It is well understood in the electrical art that the movement of a coil through magnetic lines of force will generate an electromotive force in the coil. It is also known that when a coil under the influence of a magnet is moved by an oscillating member, such as a diaphragm, that the maximum electromotive force in the coil is generated during the highest speed of movement of the diaphragm, and that when the diaphragm has been moved to its furthest point from its normal position, there is the status that the coil is at rest for an instant before it starts in the reverse direction and that no lines of force are being cut and that there is maximum pressure against the under side of the diaphragm. Consequently, in referring to Fig. 19, the point 127 on a known pressure curve, which indicates the maximum pressure of the gas in the cylinder, is directly above the point on the curve on the film where it crosses the abscissa, that is, there is no movement of the coil to cut magnetic lines of force. As the pressure is reduced in the engine, due to the downward movement of the piston, the diaphragm moves back to normal position and in doing so cuts magnetic lines of force generating

base 49, a light-proof container 69 for carrying the operating parts of the apparatus, and a film magazine 70, suitably positioned on top of the container. Power is supplied to the apparatus by means of a motor (not shown) through a belt 71 operating on pulley 72 for driving a main shaft 73. A fly wheel 74 operated by the main shaft through a series of gears maintains the moving parts of the apparatus at uniform speeds. Referring also to Fig. 10, there is shown a suitable off-center arrangement for transmitting power at a reduced speed to a set of rollers located in the lower part of the container and preferably consists of a rotating blank wheel 75 driven by gears operated from the main shaft, levers 76 and 77 adjustably positioned off center on the blank by means of a movable quadrant 78, and a toothed wheel 79 mounted on a shaft 80 carrying one of the rollers driven by the levers 76 and 77 operating through engaging pawls 81 and 82, as shown in detail in Fig. 11. The two levers carrying the pawls 81 and 82 are mounted on the shaft 80 and are free to be oscillated about that shaft, thus the movements of the levers 76 and 77 are independent and the two levers that carry the pawls are likewise independent and separately movable. From the description of the foregoing apparatus it will be readily seen that the speed of the roller may be increased or decreased by moving the pivoted ends of the levers away from or toward the center of the blank wheel 75.

Referring to Fig. 12, the apparatus mounted on the opposite outside surface of the container 69 consists of a main operating handle 83 for throwing the operating parts of the camera into and out of operation, a wheel 84 slidably carried on the shaft 85 which also carries one of the driving rollers for moving the film, and pivoted levers which operate with the movement of the operating handle to throw certain parts of the apparatus into operating position. Suitable pulleys 86 and 87 connected by a belt 88 transmit power to a guiding roller 130 (see Fig. 17) which assists in moving the film through suitable developer and fixing baths. A handle 89 is provided to manually rotate the guiding roller when desired.

Referring particularly to Figs. 14 to 17 inclusive, a description of the operation of the camera will be made while following the path of the film through the camera. A door 90 pivoted on the container 69 is opened and the film drawn from the magazine down across an oscillating spring biased guide 91 and into contact with a driving roller 92. The operating handle is then moved to its "up" position moving a second driving roller 93 against the film thereby firmly engaging the same between the rollers which in normal operation draw it from the magazine. The apparatus for moving this second driving roller preferably consists of a suitable cam 94 (see Fig. 13) mounted on the hub of the operating handle for moving a lever 95 backward to rotate shaft 96 carrying lever 97 upon which the roller is mounted. After the film is properly threaded between the driving rollers, the door is closed and a guard 98 surrounding the lens 64 mounted in the door moves its velvet covered edges into contact with the film and presses the same against the guide 91 thus making the enclosure between the door and the interior of the container light-proof. A second guard 99 held on the front of the door carries the oscillating plates 66 and 67 which are movable by thumb screw 100 (see Fig. 14) to increase or decrease the width of the light beam admitted to the lens 64. Preferably these plates are adjusted so that the width of the opening is less than the shadow cast by the spokes of the phonic wheel.

The movement of the operating handle to its "up" position oscillates an apertured cylinder 101 mounted in a cylindrical tapering seat in a second apertured cylinder 102 (see Fig. 17) so that apertures 103 and 104 register and permit the film as moved by the driving rollers to pass therethrough into contact with a guiding fork 105 shown in its lower or "down" position in dotted lines. This fork guides the end of the film from the driving rollers to a second set of rollers 106 and 107, and is maintained in its lower position until the film is caught by these lower rollers, when it is automatically thrown to its "up" position, represented in full lines, and the film is then allowed to double back on itself, as shown in full lines, and to be stored within the container until the lower rollers draw the same forward and move it through developer and fixing liquids maintained in the tank. Proper guiding means such as a V-shaped guide 108 is held in the tank 68 to guide the film through the developing fluids. From the above description it will be noted that the camera exposes the film at one rate of speed and develops it at another rate, this last rate of speed being variable by means of the apparatus above described.

Referring now to Figs. 12, 13, 15 and 16, the operation of the guiding fork and its mechanism will be set forth. Preferably this guiding fork is thrown to its "down" position by the upward movement of the operating handle, and is automatically moved to its "up" position after the power has been applied to the camera for a definite period of time. The mechanism required to move the fork to its "down" position preferably consists of a train of levers 109, 110, [illegible] and 112 and wheel 84. The upward movement of the handle carries lever 109 upward and a leaf spring 113 attached

which, being attached to the end of the fourth lever 112, rotates the same about its pivot 131, and moves its free end upward and out of contact with the side of wheel 84. The fork is mounted on shaft 114. The wheel 84 is mounted on shaft 85 carrying one of the driving rollers and is biased by a compression spring 115 to a position near the side of the container. This wheel has on the end of its hub a cam 116 which engages a pin 117 carried in the shaft. The end of the fourth lever engages the top or circumferential surface of the wheel when the fork has been moved to its "down" position, and the levers are in positions shown in Figs. 12 and 16. When the power is applied, pin 117 moves in contact with the cam forcing the wheel outward and compressing spring 115 until the pin reaches the end of the cam at that instant the fourth lever has moved out of contact with the circumferential surface of wheel 84 and is thrown by spring 118 against the hub of the wheel and into contact with the side thereof to maintain the same in its outer position. The spring 118 mounted on the pivot of the fourth lever is of sufficient strength to throw the other attached levers and consequently the fork is rotated to its "up" position, as shown in full lines in Fig. 17. The positions of the levers after being moved are shown in Figs. 13 and 15. When the fork is in "up" position the film is permitted to double back on itself between guides 119 and is later drawn between the lower rollers and moved into the developing fluids.

When the operating handle is moved to its "down" position to stop the movement of the paper by moving the second driving roller out of contact with the first one, a sharp edge 120 formed at an angle to the center line of the apertured cylinder 101 (see Fig. 18) is progressively moved against the other apertured cylinder 102 to cut the film. The remaining parts of the apparatus continue to operate until the lower rollers have moved the film held in storage through the developer and fixing baths and the guiding rollers 130 has moved the film from the developer solution.

Referring now to Fig. 20, which represents the permanent film as it issues from the camera, the movements of the diaphragm of the indicator are shown as recorded on the film. The lines extending across the film represent the shadows cast by the spokes of the phonic wheel and, as hereinbefore stated, indicate time intervals of one one-hundredth of a second. The middle or upper line illustrates the movement of the diaphragm in the indicator and since it is responsive to the pressure in the cycle of operation of the engine. The portion of the curve between the points 121 and 122 indicates the pressure variation in the cylinder during a compression stroke of the engine, and the expansion thereof without the firing or burning of the gases is shown next to the right. The induction or suction stroke of the engine is illustrated at point 123 and a second compression stroke is illustrated at 124 and the firing of the gases takes place at 125 which is just prior to the completion of the upward movement of the piston. The pressure variation during the burning of the gases in the cylinder is represented by the wide movement in the curve in this figure and the operation of the exhaust valve is shown as commencing at the point 126.

The lower curve illustrates the movements of the second vibrating wire 9 and shows the passing of current through that wire by means of the operation of the switch associated with the crank shaft in the engine. Since the position of nub 10 on the crank shaft to close this switch is known with respect to the position of the piston in cylinder 5, the time of the firing of the gases and the movements of the inlet and exhaust valves in respect to the engine shaft are readily determined. The distance of any part of the curve from its normal indicates the variation of the intensity of the gas pressures in the cylinders. It is well understood in the electrical art that the movement of a coil through magnetic lines of force will generate an electromotive force in the coil. It is also known that when a coil under the influence of a magnet is moved by an oscillating member, such as a diaphragm, that the maximum electromotive force in the coil is generated during the highest speed of movement of the diaphragm, and that when the diaphragm has been moved to its furthest point from its normal position, there is the status that the coil is at rest for an instant before it starts in the reverse direction and that no lines of force are being cut and that there is maximum pressure against the under side of the diaphragm. Consequently, in referring to Fig. 19, the point 127 on a known pressure curve, which indicates the maximum pressure of the gas in the cylinder, is directly above the point on the curve on the film where it crosses the abscissa, that is, there is no movement of the coil to cut magnetic lines of force. As the pressure is reduced in the engine, due to the downward movement of the piston, the diaphragm moves back to normal position and in doing so cuts magnetic lines of force generating electromotive force the intensity of which is indicated by the part of the curve extending below the abscissa. The ordinate of the

pressure curve 128 is represented by P and the abscissa by T for the time. The lower curve 129 in the figure being developed by the herein described recording indicator represents increment changes in pressures during increments of time, and therefore the ordinate represents

$$\frac{dp}{dt},$$

showing the extent of the increament changes, The abscissa of this curve represents time. The curves represented in Fig. 19 are those of pressures of gases in a gas engine cylinder during the compression and expansion strokes without the gases being ignited, the top curve representing the actual pressure and the lower curve representing pressure variations obtained by the recording indicator.

The indications of the conditions of the gases in the cylinder indicated by the curves on the film may be interpolated to determine the exact intensities in pounds per square inch and the time of duration of these pressures; and the variations in pressures during the compression of the gases may be determined from the small vibrations in the curve. The position of the piston in the cylinder as related to the crank shaft is determined by the position of the indication of the lower curve.

The foregoing description of the apparatus and the operation of the recording indicator is directed to the variations in pressures of a single cylinder and to the relation of these pressures to the position of the piston. It is to be understood that the carrying block 28 may be increased in size and that several vibrating wires from several different cylinders may be held therein and their indications represented on the film 4 as described. If desired, the film may be of greater width to accommodate the operation of several additional vibrating wires, but this would necessitate only a change in degree of the apparatus herein described.

The subject matter of the camera portion of this application has been claimed in a copending application entitled Cameras, filed January 30, 1922, S. N. 532,591.

This invention may be variously embodied and the particular embodiment shown may be modified within the scope of the subjoined claims.

We claim:

1. In an indicator the combination of a member movable at high speeds and adapted to be responsive to minute variations in in proportionate relation to the intensity of the force moving said member, an indicating means influenced by the generated electromotive force, and means for recording the indications made by said indicating means.

2. In a recording indicator the combination of a member movable at high speeds, an electrical conducting coil positioned in a magnetic field and moved by said member, and a small wire of low inertia electrically connected to said electrical coil and movable in a magnetic field, and means for recording the movements of said wire.

3. In a recording indicator the combination of a member movable at high speeds, an electrical conducting coil juxtaposed to said member and held in a magneitc field, and a wire connected to said coil and held in another magnetic field and movable when electrical energy passes therethrough, and means for recording the movements of said wire.

4. In a recording indicator the combination of a member movable at high speeds, an electrical coil movable with said member, a magnet having its poles within and around said coil, a small conducting wire held in a magnetic field and connected to said coil, and means for recording the movements of said wire as electrical energy formed in said electric coil by its movements in the magnetic field passes through said wire.

5. In an apparatus as described the combination of a mechanically moving member, an electrical means associated with said member and adapted to generate electromotive force when moved by said member, an electrical conducting wire of low inertia connected to said electrical means and positioned within a magnetic field, said wire being capable of movement from its normal position as the electromotive force passes through it, and means for recording the movements of said wire.

6. In a recording indicator, the combination of a diaphragm of rapid free period of vibration movable at high speeds, an electrical coil moved by said diaphragm, a magnet creating magnetic lines of force in the path of said coil, a wire of small inertia held in a magnetic field and electrically connected to said coil to receive electromotive force generated therein, and means for recording the movements of said wire.

7. In a recording indicator the combination of a member movable at high speeds

member will cause the generation of electromotive force in said conductor, an electroresponsive means connected to said conductor for indicating the electromotive force generated, the indications being in proportion to the intensity of the force moving said member, means for projecting the movement of said electroresponsive means, and a moving sensitized film for receiving the projections.

8. In a recording indicator the combination of a member movable at high speeds, electrical means associated with said member having a small wire movable in known relation therewith, a light projecting means for projecting the movements of said wire, and a rapidly moving sensitized film exposed to said light for recording said projections.

9. In a recording indicator the combination of a member movable at high speeds, electrical generating means associated with said member, a small wire remotely placed and connected to said electrical means and responsive to energy generated therein, a light projecting means for projecting the movements of said wire, a rapidly moving sensitized film for receiving the projections and for recording said projections, and means for indicating time elements on said film.

10. In a recording indicator the combination of a diaphragm movable at high speeds, electrical means associated with said diaphragm and adapted to generate electrical energy, means for indicating the intensity and duration of said energy, and a light projecting means for projecting the indications, a sensitized film for receiving said projections, and means for indicating time intervals on said film.

11. In a recording indicator, the combination of a diaphragm movable at high speeds, an electrical coil associated therewith, a magnet for producing a magnetic field around said coil, a small wire connected to said coil and influenced by a second magnetic field, a light beam illuminating said wire, a sensitized film for receiving said beam of light and the shadow cast by said wire, and means for indicating on said paper intervals of time.

12. In a recording indicator the combination of a diaphragm movable at high speeds, a magnet positioned near said diaphragm, an electrical coil movable by said diaphragm and in the field of said magnet for generating electrical energy, a wire held in another magnetic field and connected to said coil and adapted to be variably moved from its normal position by the intensity of the energy indicating on said film the passing of intervals of time.

13. In a recording indicator the combination of an induction coil capable of rapid movement in a magnetic field, a wire connected to said coil and positioned in another magnetic field, and means for recording the movement of said wire.

14. In a recording apparatus the combination of a rapidly moving member, mechanical means attached to said member for transmitting the movements thereof, an electrical generating means associated with and operated by said mechanical means, a movable indicator connected with said generating means and responsive in degree to the amount of energy generated, and means for recording the movements of said indicator.

15. In a recording indicator the combination of a flexible diaphragm responsive to pressures in an internal combustion engine, an electrical coil carried by said diaphragm and movable in a magnetic field, a vibrating member also movable in a magnetic field and electrically connected to said coil and adapted to vibrate in proportion to the electromotive force developed in said coil, lighting means for illuminating said vibrating member, and a sensitized film in the path of said light.

16. In a recording indicator the combination of a flexible diaphragm responsive to pressures in an internal combustion engine, an electrical coil carried by said diaphragm and movable in a magnetic field, a vibrating member also movable in a magnetic field and electrically connected to said coil and adapted to vibrate in proportion to the electromotive force developed in said coil, lighting means for illuminating said vibrating member, and a rapidly moving sensitized film exposed to a light beam from said lighting means, the positions of the shadow cast by said vibrating member in said light beam indicating the positions of said diaphragm.

17. In a recording indicator the combination of a movable diaphragm responsive to the varying pressures in a cylinder of an internal combustion engine, an induction coil carried by said diaphragm and movable in an adjustably positioned magnetic field, a magnetically influenced vibrating wire connected to said induction coil and movable in proportion to electromotive force developed in said coil, a beam of light for illuminating said wire, and a rapidly moving sensitized film in the path of said light for recording the position of said wire in said beam of light.

18. In a recording indicator the combination of an indicator attached to an internal

pressure curve 128 is represented by P and the abscissa by T for the time. The lower curve 129 in the figure being developed by the herein described recording indicator represents increment changes in pressures during increments of time, and therefore the ordinate represents

$$\frac{dp}{dt},$$

showing the extent of the increament changes, The abscissa of this curve represents time. The curves represented in Fig. 19 are those of pressures of gases in a gas engine cylinder during the compression and expansion strokes without the gases being ignited, the top curve representing the actual pressure and the lower curve representing pressure variations obtained by the recording indicator.

The indications of the conditions of the gases in the cylinder indicated by the curves on the film may be interpolated to determine the exact intensities in pounds per square inch and the time of duration of these pressures; and the variations in pressures during the compression of the gases may be determined from the small vibrations in the curve. The position of the piston in the cylinder as related to the crank shaft is determined by the position of the indication of the lower curve.

The foregoing description of the apparatus and the operation of the recording indicator is directed to the variations in pressures of a single cylinder and to the relation of these pressures to the position of the piston. It is to be understood that the carrying block 28 may be increased in size and that several vibrating wires from several different cylinders may be held therein and their indications represented on the film 4 as described. If desired, the film may be of greater width to accommodate the operation of several additional vibrating wires, but this would necessitate only a change in degree of the apparatus herein described.

The subject matter of the camera portion of this application has been claimed in a copending application entitled Cameras, filed January 30, 1922, S. N. 532,591.

This invention may be variously embodied and the particular embodiment shown may be modified within the scope of the subjoined claims.

We claim:

1. In an indicator the combination of a member movable at high speeds and adapted to be responsive to minute variations in the moving force, and electrical conducting means moved by said member and being so arranged in a magnetic circuit that an electromotive force will be generated in said conducting means during its movement, the intensity of said electromotive force being in proportionate relation to the intensity of the force moving said member, an indicating means influenced by the generated electromotive force, and means for recording the indications made by said indicating means.

2. In a recording indicator the combination of a member movable at high speeds, an electrical conducting coil positioned in a magnetic field and moved by said member, and a small wire of low inertia electrically connected to said electrical coil and movable in a magnetic field, and means for recording the movements of said wire.

3. In a recording indicator the combination of a member movable at high speeds, an electrical conducting coil juxtaposed to said member and held in a magneitc field, and a wire connected to said coil and held in another magnetic field and movable when electrical energy passes therethrough, and means for recording the movements of said wire.

4. In a recording indicator the combination of a member movable at high speeds, an electrical coil movable with said member, a magnet having its poles within and around said coil, a small conducting wire held in a magnetic field and connected to said coil, and means for recording the movements of said wire as electrical energy formed in said electric coil by its movements in the magnetic field passes through said wire.

5. In an apparatus as described the combination of a mechanically moving member, an electrical means associated with said member and adapted to generate electromotive force when moved by said member, an electrical conducting wire of low inertia connected to said electrical means and positioned within a magnetic field, said wire being capable of movement from its normal position as the electromotive force passes through it, and means for recording the movements of said wire.

6. In a recording indicator, the combination of a diaphragm of rapid free period of vibration movable at high speeds, an electrical coil moved by said diaphragm, a magnet creating magnetic lines of force in the path of said coil, a wire of small inertia held in a magnetic field and electrically connected to said coil to receive electromotive force generated therein, and means for recording the movements of said wire.

7. In a recording indicator the combination of a member movable at high speeds and arranged to be responsive to minute variations in the force which moves said member, an electrical conductor so positioned in a magnetic circuit that movements of said conductor due to a mechanical connection between it and said movable

troresponsive means connected to said conductor for indicating the electromotive force generated, the indications being in proportion to the intensity of the force moving said member, means for projecting the movement of said electroresponsive means, and a moving sensitized film for receiving the projections.

8. In a recording indicator the combination of a member movable at high speeds, electrical means associated with said member having a small wire movable in known relation therewith, a light projecting means for projecting the movements of said wire, and a rapidly moving sensitized film exposed to said light for recording said projections.

9. In a recording indicator the combination of a member movable at high speeds, electrical generating means associated with said member, a small wire remotely placed and connected to said electrical means and responsive to energy generated therein, a light projecting means for projecting the movements of said wire, a rapidly moving sensitized film for receiving the projections and for recording said projections, and means for indicating time elements on said film.

10. In a recording indicator the combination of a diaphragm movable at high speeds, electrical means associated with said diaphragm and adapted to generate electrical energy, means for indicating the intensity and duration of said energy, and a light projecting means for projecting the indications, a sensitized film for receiving said projections, and means for indicating time intervals on said film.

11. In a recording indicator, the combination of a diaphragm movable at high speeds, an electrical coil associated therewith, a magnet for producing a magnetic field around said coil, a small wire connected to said coil and influenced by a second magnetic field, a light beam illuminating said wire, a sensitized film for receiving said beam of light and the shadow cast by said wire, and means for indicating on said paper intervals of time.

12. In a recording indicator the combination of a diaphragm movable at high speeds, a magnet positioned near said diaphragm, an electrical coil movable by said diaphragm and in the field of said magnet for generating electrical energy, a wire held in another magnetic field and connected to said coil and adapted to be variably moved from its normal position by the intensity of the energy generated in said coil, light means illuminating said wire, a sensitized film for recording the positions of said wire, and means for

13. In a recording indicator the combination of an induction coil capable of rapid movement in a magnetic field, a wire connected to said coil and positioned in another magnetic field, and means for recording the movement of said wire.

14. In a recording apparatus the combination of a rapidly moving member, mechanical means attached to said member for transmitting the movements thereof, an electrical generating means associated with and operated by said mechanical means, a movable indicator connected with said generating means and responsive in degree to the amount of energy generated, and means for recording the movements of said indicator.

15. In a recording indicator the combination of a flexible diaphragm responsive to pressures in an internal combustion engine, an electrical coil carried by said diaphragm and movable in a magnetic field, a vibrating member also movable in a magnetic field and electrically connected to said coil and adapted to vibrate in proportion to the electromotive force developed in said coil, lighting means for illuminating said vibrating member, and a sensitized film in the path of said light.

16. In a recording indicator the combination of a flexible diaphragm responsive to pressures in an internal combustion engine, an electrical coil carried by said diaphragm and movable in a magnetic field, a vibrating member also movable in a magnetic field and electrically connected to said coil and adapted to vibrate in proportion to the electromotive force developed in said coil, lighting means for illuminating said vibrating member, and a rapidly moving sensitized film exposed to a light beam from said lighting means, the positions of the shadow cast by said vibrating member in said light beam indicating the positions of said diaphragm.

17. In a recording indicator the combination of a movable diaphragm responsive to the varying pressures in a cylinder of an internal combustion engine, an induction coil carried by said diaphragm and movable in an adjustably positioned magnetic field, a magnetically influenced vibrating wire connected to said induction coil and movable in proportion to electromotive force developed in said coil, a beam of light for illuminating said wire, and a rapidly moving sensitized film in the path of said light for recording the position of said wire in said beam of light.

18. In a recording indicator the combination of an indicator attached to an internal combustion engine, a magnetically influenced vibrating wire electrically connected to said indicator and moved by the electromotive

force generated therein, a second vibrating wire electrically connected to a source of power and to a switch operated by the shaft of said internal combustion engine, said second wire held near said first vibrating wire and subject to the same magnetic influence, a beam of light for illuminating said wires, and a rapidly moving sensitized film in the path of said light for recording the positions of the shadows created by said wires.

19. A recording indicator comprising a diaphragm moved by the varying gas pressures in an internal combustion engine, an electrical coil carrying bobbin attached to said diaphragm and movable therewith, a magnet having one part of its core held within said coil and another part surrounding the outside thereof, means for exciting said magnet, a fine wire electrically connected to said coil and adjustably positioned between two parts of a core of a second magnet to be moved by the influence of electric energy passing therethrough and by the magnetic forces created by the second magnet, a source of light for projecting light beams through lens and on to said wire, a spoked wheel rotating at uniform speed by means of a motor rotating in synchronism with an electrically operating tuning fork for interrupting said beams of light at definite time intervals, a camera having a uniformly moved sensitized film passing in front of an aperture provided with a condensing lens and adapted to have said light beams projected thereon to indicate the positions of said wire and said spokes as said wire and said spokes are moved in the path of said light beams, and rollers for moving said sensitized film to developer and fixing baths at a speed different from its speed in front of said aperture.

20. A recording indicator comprising a diaphragm moved by the varying gas pressures in an internal combustion engine, a bobbin carrying an electrical coil attached to said diaphragm and movable therewith, a magnet having one part of its core held within said coil and another part surrounding the outside thereof, means for exciting said magnet, a fine wire electrically connected to said coil and adjustably positioned between two parts of a core of a second magnet to be moved by the influence of electric energy passing therethrough and by the forces created by the second magnet, a second vibrating wire electrically connected to a source of power and to a switch operated by the shaft of said internal combustion engine, said second wire held near said first vibrating wire and subject to the same tuning fork for interrupting said beams of light at definite time intervals, a camera having a sensitized film passing at a uniform speed in front of an aperture provided with a condensing lens and adapted to have said light beams projected thereon to indicate the posititons of said wires and said spokes as said wires and said spokes are moved in the path of said light beams, and rollers for moving said sensitized film to developer and fixing baths at a speed different from the speed in passing said aperture.

21. In a recording indicator having an indicator part comprising a diaphragm adapted to be rapidly moved, a bobbin carrying an electric coil and being firmly attached to said diaphragm, and an adjustably positioned magnet for producing a magnetic field around said coil to generate electromotive force in said coil as it moves in said magnetic field.

22. In a recording indicator having an indicator part comprising a diaphragm movable in response to varying pressure, a bobbin carrying an electric coil attached to said diaphragm and movable therewith, a separately excited magnet for producing a magnetic field around said bobbin, and means for conducting electromotive force generated in said coil by its movement in said magnetic field to a remote point.

23. In a recording indicator having an indicator part comprising a frame, a diaphragm of rapid free period of vibration held therein and adapted to be readily moved, a bobbin attached to said diaphragm and carrying an electrical coil, a magnet positioned in said frame and having part of its core held within said coil and another part of its core held on the outside of said coil, and means for holding said magnet in several positions to have greater or less magnetic lines of force cut by said coil during its movement with said diaphragm.

24. In a recording indicator having an indicator part comprising a frame, a vibrating diaphragm positively held in said frame, a tubular opening in the lower part of said frame provided with means for attaching the same to an internal combustion engine, a valve in said tubular opening to admit gases under pressure from said engine to one side of said diaphragm, a standard firmly attached to the center of said diaphragm and movable therewith, an insulating member carried on said standard, a coil wound on said insulating member and having leads extending to binding posts held on said frame, a separately excited magnet

and means for separately exciting said magnet.

25. In an electrical instrument a magnet for creating a magnetic field, and an electrical conductor held in said field and adapted to be vibrated by an external force thereby generating an electromotive force in said conductor, the pole pieces of said magnet being arranged to be moved at will relatively to said conductor to produce a variation in the effectiveness of said magnetic field on said conductor thereby effecting the amount of electromotive force generated when said conductor is moved.

26. In an electrical instrument an electromagnet having a closed magnetic circuit except for a small air gap, and a coil of electrically conductive material normally suspended in said air gap and adapted to be free to move therein, said magnet and said coil being so arranged that one of them may be materially moved relatively to the other to change the effectiveness on said coil of the magnetic field created by said magnet.

27. In an electrical instrument an electromagnet having a closed magnetic circuit except for a small air gap, a coil adapted to be suspended in said air gap and arranged to have free movement therein, and means for moving said coil within the magnetic field created by said magnet to generate an electromotive force, said magnet adapted to have its pole pieces movable relatively to said coil to increase or decrease the intensity of the magnetic field in which said coil moves thus varying the amount of the electromotive force generated.

28. In a recording indicator a member adapted to be moved at high speeds, a small coil mounted on a means attached to said member so that said coil is moved in unison with said member, an electromagnet so constructed as to have a small annular air gap and being so positioned in relation to said member and said coil as to have said coil suspended in said air gap, the movement of said coil in a magnetic field created by said magnet causing the generation of an electromotive force in said coil, said magnet adapted to be moved to and from said coil to vary the intensity of the magnetic field in which said coil moves thereby varying the amount of the electromotive force generated, means for positively holding said magnet in its various positions, and an indicating means operated by the electromotive force generated in said coil to show the intensity of movement of said member.

In testimony whereof, we have signed our names to this specification this first day of October, 1920.

AUGUSTUS TROWBRIDGE.
WILLIAM C. DURYEA.

force generated therein, a second vibrating wire electrically connected to a source of power and to a switch operated by the shaft of said internal combustion engine, said second wire held near said first vibrating wire and subject to the same magnetic influence, a beam of light for illuminating said wires, and a rapidly moving sensitized film in the path of said light for recording the positions of the shadows created by said wires.

19. A recording indicator comprising a diaphragm moved by the varying gas pressures in an internal combustion engine, an electrical coil carrying bobbin attached to said diaphragm and movable therewith, a magnet having one part of its core held within said coil and another part surrounding the outside thereof, means for exciting said magnet, a fine wire electrically connected to said coil and adjustably positioned between two parts of a core of a second magnet to be moved by the influence of electric energy passing therethrough and by the magnetic forces created by the second magnet, a source of light for projecting light beams through lens and on to said wire, a spoked wheel rotating at uniform speed by means of a motor rotating in synchronism with an electrically operating tuning fork for interrupting said beams of light at definite time intervals, a camera having a uniformly moved sensitized film passing in front of an aperture provided with a condensing lens and adapted to have said light beams projected thereon to indicate the positions of said wire and said spokes as said wire and said spokes are moved in the path of said light beams, and rollers for moving said sensitized film to developer and fixing baths at a speed different from its speed in front of said aperture.

20. A recording indicator comprising a diaphragm moved by the varying gas pressures in an internal combustion engine, a bobbin carrying an electrical coil attached to said diaphragm and movable therewith, a magnet having one part of its core held within said coil and another part surrounding the outside thereof, means for exciting said magnet, a fine wire electrically connected to said coil and adjustably positioned between two parts of a core of a second magnet to be moved by the influence of electric energy passing therethrough and by the forces created by the second magnet, a second vibrating wire electrically connected to a source of power and to a switch operated by the shaft of said internal combustion engine, said second wire held near said first vibrating wire and subject to the same magnetic influence, a source of light for projecting light beams through lens and on to said wires, a spoked wheel rotating at uniform speed by means of a motor rotating in synchronism with an electrically operating tuning fork for interrupting said beams of light at definite time intervals, a camera having a sensitized film passing at a uniform speed in front of an aperture provided with a condensing lens and adapted to have said light beams projected thereon to indicate the posititons of said wires and said spokes as said wires and said spokes are moved in the path of said light beams, and rollers for moving said sensitized film to developer and fixing baths at a speed different from the speed in passing said aperture.

21. In a recording indicator having an indicator part comprising a diaphragm adapted to be rapidly moved, a bobbin carrying an electric coil and being firmly attached to said diaphragm, and an adjustably positioned magnet for producing a magnetic field around said coil to generate electromotive force in said coil as it moves in said magnetic field.

22. In a recording indicator having an indicator part comprising a diaphragm movable in response to varying pressure, a bobbin carrying an electric coil attached to said diaphragm and movable therewith, a separately excited magnet for producing a magnetic field around said bobbin, and means for conducting electromotive force generated in said coil by its movement in said magnetic field to a remote point.

23. In a recording indicator having an indicator part comprising a frame, a diaphragm of rapid free period of vibration held therein and adapted to be readily moved, a bobbin attached to said diaphragm and carrying an electrical coil, a magnet positioned in said frame and having part of its core held within said coil and another part of its core held on the outside of said coil, and means for holding said magnet in several positions to have greater or less magnetic lines of force cut by said coil during its movement with said diaphragm.

24. In a recording indicator having an indicator part comprising a frame, a vibrating diaphragm positively held in said frame, a tubular opening in the lower part of said frame provided with means for attaching the same to an internal combustion engine, a valve in said tubular opening to admit gases under pressure from said engine to one side of said diaphragm, a standard firmly attached to the center of said diaphragm and movable therewith, an insulating member carried on said standard, a coil wound on said insulating member and having leads extending to binding posts held on said frame, a separately excited magnet adjustably held in said frame and having one of its poles adapted to enter said standard and to be held within said coil and having its other pole of circular shape surrounding said insulating member and said coil,

25. In an electrical instrument a magnet for creating a magnetic field, and an electrical conductor held in said field and adapted to be vibrated by an external force thereby generating an electromotive force in said conductor, the pole pieces of said magnet being arranged to be moved at will relatively to said conductor to produce a variation in the effectiveness of said magnetic field on said conductor thereby effecting the amount of electromotive force generated when said conductor is moved.

26. In an electrical instrument an electromagnet having a closed magnetic circuit except for a small air gap, and a coil of electrically conductive material normally suspended in said air gap and adapted to be free to move therein, said magnet and said coil being so arranged that one of them may be materially moved relatively to the other to change the effectiveness on said coil of the magnetic field created by said magnet.

27. In an electrical instrument an electromagnet having a closed magnetic circuit except for a small air gap, a coil adapted to be suspended in said air gap and arranged to have free movement therein, and means for moving said coil within the magnetic field created by said magnet to generate an electromotive force in said coil, said magnet having its pole pieces movable relatively to said coil to increase or decrease the intensity of the magnetic field in which said coil moves thus varying the amount of the electromotive force generated.

28. In a recording indicator a member adapted to be moved at high speeds, a small coil mounted on a means attached to said member so that said coil is moved in unison with said member, an electromagnet so constructed as to have a small annular air gap and being so positioned in relation to said member and said coil as to have said coil suspended in said air gap, the movement of said coil in a magnetic field created by said magnet causing the generation of an electromotive force in said coil, said magnet adapted to be moved to and from said coil to vary the intensity of the magnetic field in which said coil moves thereby varying the amount of the electromotive force generated, means for positively holding said magnet in its various positions, and an indicating means operated by the electromotive force generated in said coil to show the intensity of movement of said member.

In testimony whereof, we have signed our names to this specification this first day of October, 1920.

AUGUSTUS TROWBRIDGE.
WILLIAM C. DURYEA.

1216

Nov. 13, 1923.

1,473,976

E. E. RIES

SOUND RECORDING METHOD

Original Filed May 21, 1913 2 Sheets-Sheet 1

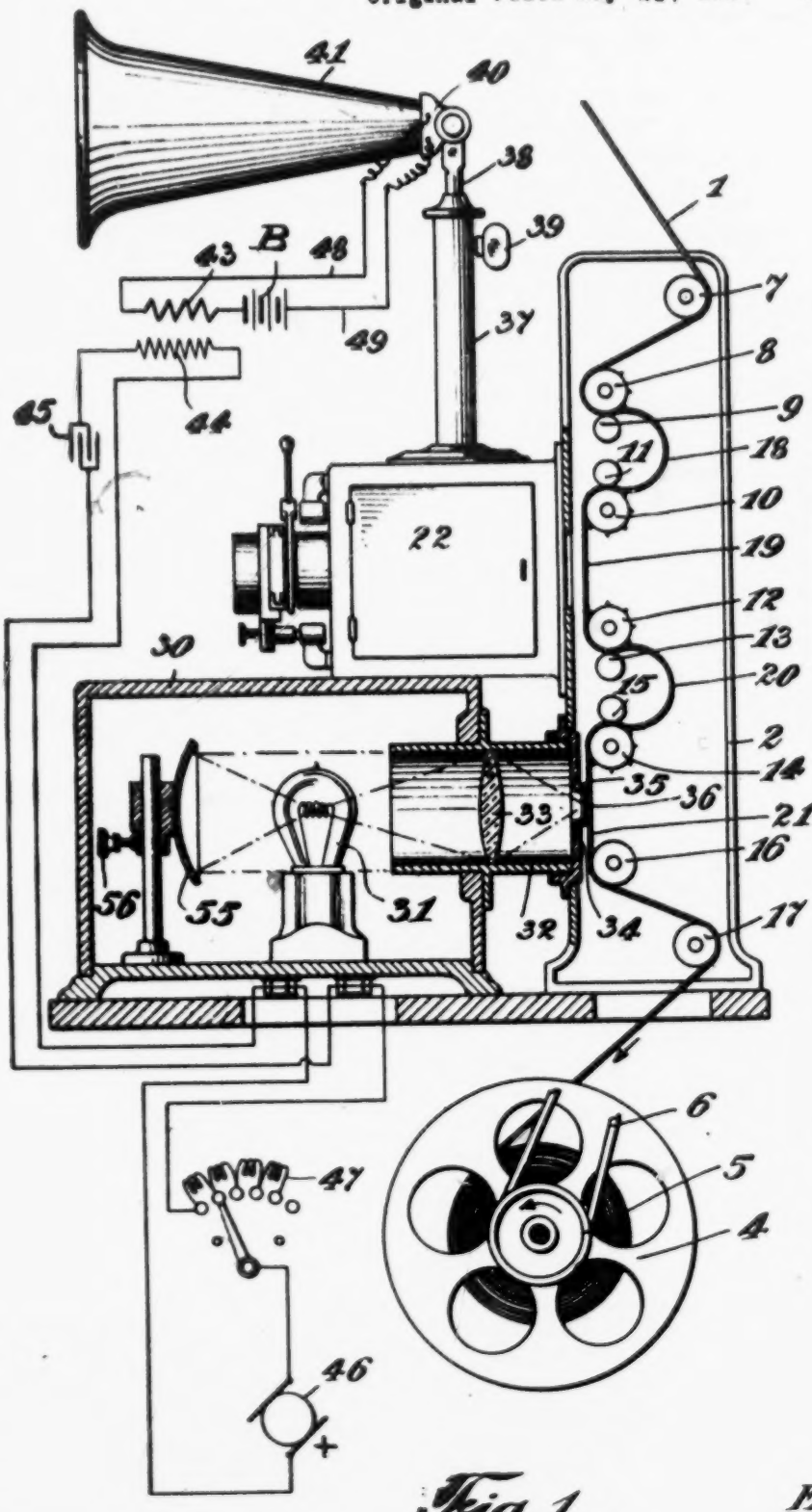

Fig. 1.

Fig. 2.

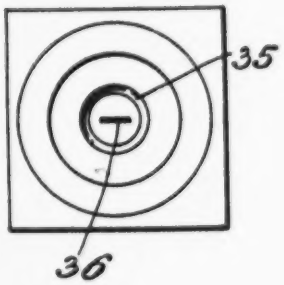

Fig. 3.

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SOUND RECORDING METHOD

Original Filed May 21, 1913 2 Sheets-Sheet 2

Fig. 4.

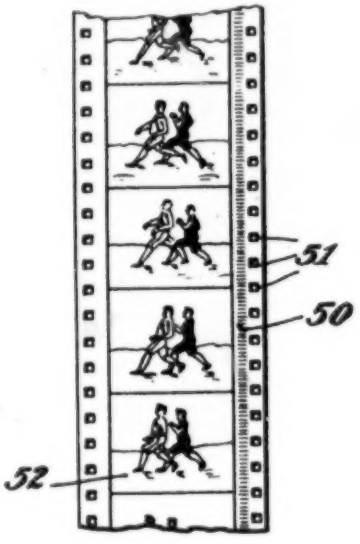


Fig. 5.

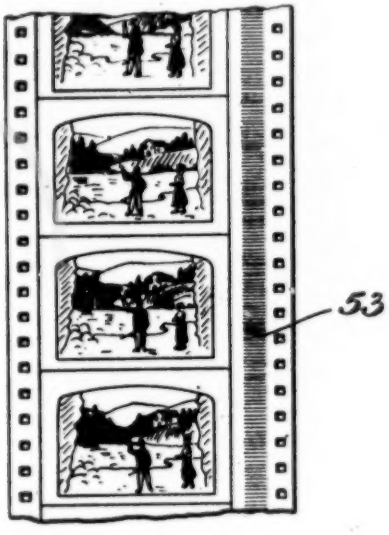


Fig. 7.

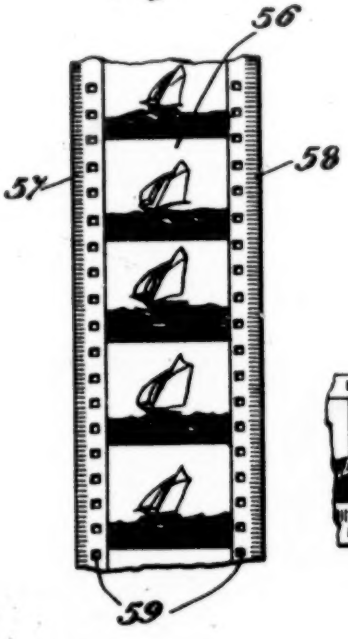
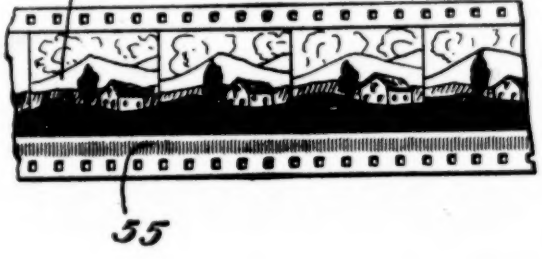


Fig. 8.

Fig. 6.



INVENTOR

Elias E. Ries

BY

George C. Dean

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Patented Nov. 13, 1923. 1,473,976

UNITED STATES PATENT OFFICE.

ELIAS E. RIES, OF NEW YORK, N. Y., ASSIGNOR TO AMERICAN AUDIOSCOPE CO., INC., A CORPORATION OF NEW YORK.

SOUND-RECORDING METHOD.

Original application filed May 21, 1913, Serial No. 769,114. Divided and this application filed April 6, 1923. Serial No. 630,197.

To all whom it may concern:

Be it known that I, ELIAS E. RIES, a citizen of the United States, and resident of New York city, in the county of New York and State of New York, have invented certain new and useful Improvements in Sound-Recording Methods, of which the following is a specification.

My present invention relates to methods for the production of photographic records of sounds, whether vocal, musical or of other character, and of type such that the original sound can be accurately reproduced therefrom with facility. The invention, although in certain broader aspects thereof applicable to the preparation of sound records alone, has its preferred application to the production of talking picture film record, that is, to moving picture films bearing a succession of photographs of successive stages in the action, and taken in usual manner, and provided with one or more continuous sound records laterally of the picture which represent the amplitudes and phases of vibrations of the sonorous action, such as music, speech or the like, occurring and recorded simultaneously with the visual action.

The sound record is produced according to my invention, by causing undulatory variations in light intensity similar in form to the vibrations of the air accompanying the sonorous action, and subjecting narrow portions of the film in rapid succession to the influence of the varying light. The source of light is preferably a tungsten or other metal filament lamp of small power, although an arc lamp may be used, and the variations are imposed preferably by the well-known singing art principle, in which the sound vibrations act upon a microphone, which automatically varies resistance in circuit with the lamp, in conformity with the sound vibrations, and effects synchronously therewith, undulatory variations in the light intensity. The exposure of the film to the varying light at any moment is limited to a portion definitely restricted in the direction lengthwise of the film, by sitized surface in close proximity or contact with an opaque screen having a very small aperture. This aperture or window is preferably in the form of a narrow slit, and is of much greater width than length, the width being governed by the available space on the photographic film outside of the usual sprocket holes or between the line of pictures and the sprocket holes when the sound record is to form part of a motion picture. For sound records only, the width of the aperture may be much greater, if desired; but the length, that is the dimension taken lengthwise of the sound record, should always be proportional to the length of the shortest sound waves to be recorded. By moving the photographic film or other sensitized surface in close contact with the perforated screen, the exposed area of the sensitized surface is definitely fixed under all conditions of light, and all diffusion of light beyond the area of the aperture is prevented so far as possible. It is preferred, moreover, to focus the light from the lamp in a pointed or conical pencil directed upon the window opening, as by the use of an appropriate spherical lens. The film is moved preferably at a uniform rate past the window aperture or slit, in photographing the sonorous action, at a speed such as to differentiate the imprints of the denser and more attenuated parts of the sound waves photographed seriatim, the period of photographic exposure being so related to the speed of the record and to the duration of said portions of sound waves as to prevent blurring or overlapping. By the combined use of the photographic film moving in close contact with the screen having the small window aperture and the focusing lens, the light from the lamp acts uniformly over the exposed part of the film, so that sharper variations in light intensity are imposed upon the successively exposed parts of the film, producing more distinct and more substantial differentiations in translucency of the developed film for better sound reproduction, than if the light were more widely

E. E. RIES

SOUND RECORDING METHOD

Original Filed May 21, 1913 2 Sheets-Sheet 2

Fig. 4.

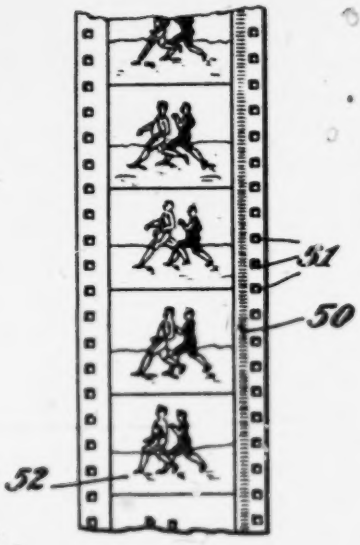

Fig. 5.

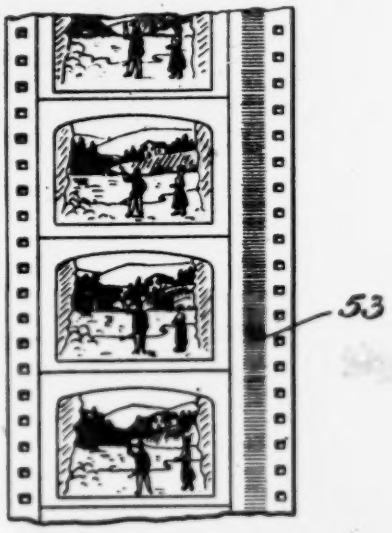

Fig. 7.

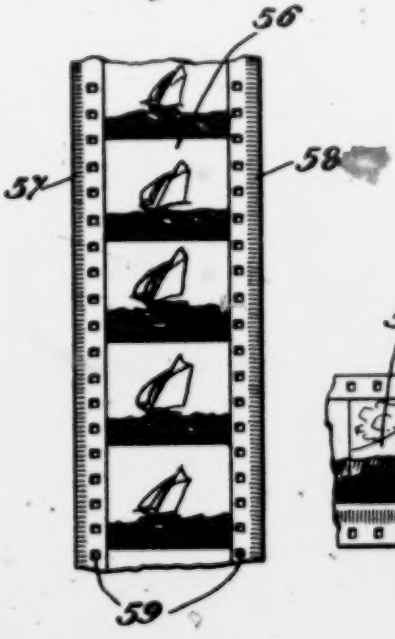

Fig. 8.

Fig. 6.

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UNITED STATES PATENT OFFICE.

ELIAS E. RIES, OF NEW YORK, N. Y., ASSIGNOR TO AMERICAN AUDIOSCOPE CO., INC., A CORPORATION OF NEW YORK.

SOUND-RECORDING METHOD.

Original application filed May 21, 1913, Serial No. 769,114. Divided and this application filed April 6, 1923. Serial No. 630,197.

To all whom it may concern:

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My present invention relates to methods for the production of photographic records of sounds, whether vocal, musical or of other character, and of type such that the original sound can be accurately reproduced therefrom with facility. The invention, although in certain broader aspects thereof applicable to the preparation of sound records alone, has its preferred application to the production of talking picture film record, that is, to moving picture films bearing a succession of photographs of successive stages in the action, and taken in usual manner, and provided with one or more continuous sound records laterally of the picture which represent the amplitudes and phases of vibrations of the sonorous action, such as music, speech or the like, occurring and recorded simultaneously with the visual action.

The sound record is produced according to my invention, by causing undulatory variations in light intensity similar in form to the vibrations of the air accompanying the sonorous action, and subjecting narrow portions of the film in rapid succession to the influence of the varying light. The source of light is preferably a tungsten or other metal filament lamp of small power, although an arc lamp may be used, and the variations are imposed preferably by the well-known singing art principle, in which the sound vibrations act upon a microphone, which automatically varies resistance in circuit with the lamp, in conformity with the sound vibrations, and effects synchronously therewith, undulatory variations in the light intensity. The exposure of the film to the varying light at any moment is limited to a portion definitely restricted in the direction lengthwise of the film, by moving the photographic film or other sensitized surface in close proximity or contact with an opaque screen having a very small aperture. This aperture or window is preferably in the form of a narrow slit, and is of much greater width than length, the width being governed by the available space on the photographic film outside of the usual sprocket holes or between the line of pictures and the sprocket holes when the sound record is to form part of a motion picture. For sound records only, the width of the aperture may be much greater, if desired; but the length, that is the dimension taken lengthwise of the sound record, should always be proportional to the length of the shortest sound waves to be recorded. By moving the photographic film or other sensitized surface in close contact with the perforated screen, the exposed area of the sensitized surface is definitely fixed under all conditions of light, and all diffusion of light beyond the area of the aperture is prevented so far as possible. It is preferred, moreover, to focus the light from the lamp in a pointed or conical pencil directed upon the window opening, as by the use of an appropriate spherical lens. The film is moved preferably at a uniform rate past the window aperture or slit, in photographing the sonorous action, at a speed such as to differentiate the imprints of the denser and more attenuated parts of the sound waves photographed seriatim, the period of photographic exposure being so related to the speed of the record and to the duration of said portions of sound waves as to prevent blurring or overlapping. By the combined use of the photographic film moving in close contact with the screen having the small window aperture and the focusing lens, the light from the lamp acts uniformly over the exposed part of the film, so that sharper variations in light intensity are imposed upon the successively exposed parts of the film, producing more distinct and more substantial differentiations in translucency of the developed film for better sound reproduction, than if the light were more widely diffused over the film.

This is particularly true where a small power tungsten filament or equivalent lamp is employed, operating at substantially rated current consumption, where the candle power will vary relatively widely with the relatively small increments or decrements of current due to the operation upon the microphone of the air waves accompanying the vocal or other sound.

In the preferred application to talking pictures, in which the sound record is photographed concurrently with the taking of the pictures, and upon a strip or border of the film laterally of the pictures, the rate of film advance is limited by the exigencies of moving picture requirements to a speed in the order of about one foot per second. As the sound records, unlike the visual records, should be substantially continuous, rather than discreet, they cannot be conveniently produced on the intermittently moving film, and are consequently recorded at a portion of the film beyond the shutter opening of the picture taking lens, that is, at a region where the film moves at uniform speed. In this application, the length of film momentarily exposed is highly restricted, being of a length in the order of that of a small pin hole, which length is traversed by the film, even at the relatively slow speed of moving picture operation, in the minute interval of a fraction of a sound wave.

In order that my recording method may be more clearly understood, I have shown in the drawings, more or less diagrammatically, apparatus by which the method may be executed, as well as the physical product resulting from the operation of the apparatus.

In the drawings:—

Fig. 1 is a view more or less diagrammatic, illustrating apparatus by which the method can be executed,

Fig. 2 is a detail view on an enlarged scale of one form of aperture plate for the sound camera,

Fig. 3 is a view similar to Fig. 2 of a modification,

Fig. 4 is a fragmentary view of a portion of one embodiment of phonoscopic film, produced according to my invention,

Figs. 5, 6 and 7 are views similar to Fig. 4 of modified forms of films, and;

Fig. 8 is a fragmentary view on a greatly enlarged scale, illustrating the appearance of a small segment of the sound record.

The present application is a division of my copending application, Serial No. 769,114, filed May 2, 1913.

Referring now to Fig. 1; the film 1 in its downward travel through casing 2, passes rate of speed from the upper reel (not shown) and is caused to form the upper loop 18. The film then passes between the upper intermittent sprocket 10 and its guide roller 11, down between the lower intermittent sprocket 12 and its guide roller 13, and forming the lower loop 20, thence between lower positively-driven sprocket 14 and its guide roller 15, thence downward in a vertical line under the guide roller 16 and over the guide roller 17, from which it is wound onto the lower film reel 4. Reel 4 is provided with the usual "take-up" device provided with a friction pulley or its equivalent 5 and driven by belt 6 from some uniformly revolving portion of the camera, which may be operated by hand or by a small motor (not shown) provided with a differential speed control which insures the proper taking up of the lower portion of the film at a uniform speed irrespective of the increasing diameter of the reel.

It will be observed that in addition to the two loops 18 and 20, the film in its passage, forms two vertical face sections 19 and 21, each approximately a trifle longer than the width of a single picture. The lower vertical film section 21 is in the focal plane of the sound camera 30. The upper section 19 is in the focal plane of the lens (not shown) of a moving picture camera 22 of any suitable construction, which exposes the central portion of the film shown in Figs. 4, 5, 6 or 7. The edge portion or portions of the film on which the photographic sound record is to be received are shielded from the light and are thus left unexposed during the transit of the film behind the shutter-opening of the picture-taking lens, which is preferably located, as shown, a short distance above the sound camera 30.

This sound camera consists of a casing containing an independent source of light, which may be a small tungsten or other metal-filament incandescent electric lamp 31 capable of being operated at a high degree of incandescence, although an electric arc lamp or any other suitable source of light may be used, if desired. Behind the lamp is mounted a standard 54 carrying an adjustment reflector 55 which may be secured upon the standard by the thumbscrew 56. The light of the lamp direct or reflected is thrown, as shown, by dotted lines, upon a spherical lens 33 in a tube 32 in the front of the casing 30. The tube is closed at its forward end by an adjustable cap-piece 34 having a raised central portion 35 pierced with either a narrow slit 36 (Fig. 2) or a small round or square pin hole opening 36' (Fig. 3), said cap-pieces being pref-

recorded, for instance, lateral strip or border 50 (Fig. 4) directly in front of the light opening 36.

Mounted at the upper rear portion of the apparatus is shown a standard 37 containing an adjustable sliding rod 38, that may be extended and turned to any position and locked against displacement by wing nut 39. The upper end of rod 37 has a swivel joint into which is clamped a telephone transmitter or microphone 40, which is provided with a large tapering horn or megaphone 41, designed and adapted to collect the atmospheric sound waves and to direct and focus them upon the diaphragm of the transmitter 40. The minimum height of the horn 41 when the device illustrated in Fig. 1 is used in connection with a portable motion picture camera, is such that the entire camera mechanism, including the casing 30 containing the photophonic recording appliances, may be mounted as a single, self-contained unit below the line of swing of the horn. The sound receiving horn 41, may, however, be located at any convenient point either alongside of the camera or at any desired or suitable distance from the scene and sounds, to be photographed.

The transmitter 40, whether mounted on the apparatus or located at a distance therefrom, is in electrical circuit through the line wires 48 and 49, with a battery B in series with the primary winding 43 of an induction coil, whose secondary winding 44 is in series with a condenser 45 and with the terminals of the lamp 31, as shown. All of these devices in practice, are preferably included within the casing 30 or other enclosed portion of the apparatus. The terminals of the lamp 31 are likewise independently connected in the usual manner, by means of the circuit wires shown, with a suitable source of direct current, such as the generator 46, the voltage of which is regulated by rheostat 47.

In the operation of recording talking pictures, the visible phase of the performance or other occurrence combining visible and sonorous action, is recorded by the camera 22, in the usual manner for taking moving pictures. The horn 41 is disposed in appropriate relation to intercept the sound waves and the circuit of the lamp 31 is closed. The film moves intermittently between the rollers 10 and 12, taking moving pictures on the film section 19 in the regular manner, while the film section 21 moves past the pin hole or other narrow slit 36 in the sound recording camera, continuously at a uniform speed, usually about one foot per second, that is, at the mean speed of the moving picture camera film. It will be

is opposite the usual picture aperture or window, and that film section 21 is likewise covered or screened by screen 35 except the small part opposite the aperature 36, and that the film in passing across the said screen 35 is held in such close proximity thereto by the feeding mechanism, or otherwise, that the light rays passing through the aperature 36 will act only on the film area limited by the size of said aperture.

Specifically, the sound waves entering the horn 41 from a distant point are concentrated upon the diaphragm of the microphonic transmitter 40, forcibly vibrating the same to vary the resistance of the primary circuit, containing the battery B and the primary coil 43. The latter induces undulating or alternating currents of high tension corresponding in form and frequency with the sound waves impinging upon the diaphragm, in the secondary coil 44, which currents pass across the condenser 45, and become superposed upon the steady current flowing through the lamp 31 from the dynamo or other source 46. The direct current from the source 46, it will be seen, cannot jump across the condenser 45, nor affect the induction coil 43, so that the net result of the variable current impressed upon the lamp 31 by the action of the transmitter 40 will be alternately and rapidly to increase and decrease the intensity of the light in exact accordance with the original sound waves. More particularly, induction coil 43—44 inducing currents flowing alternately in opposite directions through the lamp filament, as the microphone resistance alternately increases and decreases, those currents that flow with the normal lamp current serve to reinforce it and augment the candle power, while those that flow against the normal lamp current oppose it and cause a diminution of the normal luminosity.

The light from the lamp 31 passes into the tube 32 and impinges upon the spherical lens 33, which effectively concentrates or focuses the light upon the screen 35 so that the light passing through the fixed minute aperture 36 will act uniformly over the area of the film exposed by the aperture. The light from the lamp is thus effectively concentrated at any instant upon the relatively minute film areas momentarily exposed. Since, moreover, both the candle power and the actinic effect of the ordinary tungsten or other equivalent lamp operating at rated current consumption, change markedly with small increments or decrements of current, it follows that the degree of exposure of the film will very relatively widely with the

This is particularly true where a small power tungsten filament or equivalent lamp is employed, operating at substantially rated current consumption, where the candle power will vary relatively widely with the relatively small increments or decrements of current due to the operation upon the microphone of the air waves accompanying the vocal or other sound.

In the preferred application to talking pictures, in which the sound record is photographed concurrently with the taking of the pictures, and upon a strip or border of the film laterally of the pictures, the rate of film advance is limited by the exigencies of moving picture requirements to a speed in the order of about one foot per second. As the sound records, unlike the visual records, should be substantially continuous, rather than discreet, they cannot be conveniently produced on the intermittently moving film, and are consequently recorded at a portion of the film beyond the shutter opening of the picture taking lens, that is, at a region where the film moves at uniform speed. In this application, the length of film momentarily exposed is highly restricted, being of a length in the order of that of a small pin hole, which length is traversed by the film, even at the relatively slow speed of moving picture operation, in the minute interval of a fraction of a sound wave.

In order that my recording method may be more clearly understood, I have shown in the drawings, more or less diagrammatically, apparatus by which the method may be executed, as well as the physical product resulting from the operation of the apparatus.

In the drawings:—

Fig. 1 is a view more or less diagrammatic, illustrating apparatus by which the method can be executed,

Fig. 2 is a detail view on an enlarged scale of one form of aperture plate for the sound camera,

Fig. 3 is a view similar to Fig. 2 of a modification,

Fig. 4 is a fragmentary view of a portion of one embodiment of phonoscopic film, produced according to my invention,

Figs. 5, 6 and 7 are views similar to Fig. 4 of modified forms of films, and;

Fig. 8 is a fragmentary view on a greatly enlarged scale, illustrating the appearance of a small segment of the sound record.

The present application is a division of my copending application, Serial No. 769,114, filed May 2, 1913.

Referring now to Fig. 1; the film 1 in its downward travel through casing 2, passes in succession over the upper guide roll 7, upper positively-driven feed sprocket or drum 8, and its guide roller 9, by the action of which the film is unwound at a uniform rate of speed from the upper reel (not shown) and is caused to form the upper loop 18. The film then passes between the upper intermittent sprocket 10 and its guide roller 11, down between the lower intermittent sprocket 12 and its guide roller 13, and forming the lower loop 20, thence between lower positively-driven sprocket 14 and its guide roller 15, thence downward in a vertical line under the guide roller 16 and over the guide roller 17, from which it is wound onto the lower film reel 4. Reel 4 is provided with the usual "take-up" device provided with a friction pulley or its equivalent 5 and driven by belt 6 from some uniformly revolving portion of the camera, which may be operated by hand or by a small motor (not shown) provided with a differential speed control which insures the proper taking up of the lower portion of the film at a uniform speed irrespective of the increasing diameter of the reel.

It will be observed that in addition to the two loops 18 and 20, the film in its passage, forms two vertical face sections 19 and 21, each approximately a trifle longer than the width of a single picture. The lower vertical film section 21 is in the focal plane of the sound camera 30. The upper section 19 is in the focal plane of the lens (not shown) of a moving picture camera 22 of any suitable construction, which exposes the central portion of the film shown in Figs. 4, 5, 6 or 7. The edge portion or portions of the film on which the photographic sound record is to be received are shielded from the light and are thus left unexposed during the transit of the film behind the shutter-opening of the picture-taking lens, which is preferably located, as shown, a short distance above the sound camera 30.

This sound camera consists of a casing containing an independent source of light, which may be a small tungsten or other metal-filament incandescent electric lamp 31 capable of being operated at a high degree of incandescence, although an electric arc lamp or any other suitable source of light may be used, if desired. Behind the lamp is mounted a standard 54 carrying an adjustment reflector 55 which may be secured upon the standard by the thumbscrew 56. The light of the lamp direct or reflected is thrown, as shown, by dotted lines, upon a spherical lens 33 in a tube 32 in the front of the casing 30. The tube is closed at its forward end by an adjustable cap-piece 34 having a raised central portion 35 pierced with either a narrow slit 36 (Fig. 2) or a small round or square pin hole opening 36' (Fig. 3), said cap-pieces being preferably interchangeable. The moving film 1 travels downward in close proximity to the raised portion 35 and with that portion of its surface on which the sound is to be

recorded, for instance, lateral strip or border 50 (Fig. 4) directly in front of the light opening 36.

Mounted at the upper rear portion of the apparatus is shown a standard 37 containing an adjustable sliding rod 38, that may be extended and turned to any position and locked against displacement by wing nut 39. The upper end of rod 37 has a swivel joint into which is clamped a telephone transmitter or microphone 40, which is provided with a large tapering horn or megaphone 41, designed and adapted to collect the atmospheric sound waves and to direct and focus them upon the diaphragm of the transmitter 40. The minimum height of the horn 41 when the device illustrated in Fig. 1 is used in connection with a portable motion picture camera, is such that the entire camera mechanism, including the casing 30 containing the photophonic recording appliances, may be mounted as a single, self-contained unit below the line of swing of the horn. The sound receiving horn 41, may, however, be located at any convenient point either alongside of the camera or at any desired or suitable distance from the scene and sounds, to be photographed.

The transmitter 40, whether mounted on the apparatus or located at a distance therefrom, is in electrical circuit through the line wires 48 and 49, with a battery B in series with the primary winding 43 of an induction coil, whose secondary winding 44 is in series with a condenser 45 and with the terminals of the lamp 31, as shown. All of these devices in practice, are preferably included within the casing 30 or other enclosed portion of the apparatus. The terminals of the lamp 31 are likewise independently connected in the usual manner, by means of the circuit wires shown, with a suitable source of direct current, such as the generator 46, the voltage of which is regulated by rheostat 47.

In the operation of recording talking pictures, the visible phase of the performance or other occurrence combining visible and sonorous action, is recorded by the camera 22, in the usual manner for taking moving pictures. The horn 41 is disposed in appropriate relation to intercept the sound waves and the circuit of the lamp 31 is closed. The film moves intermittently between the rollers 10 and 12, taking moving pictures on the film section 19 in the regular manner, while the film section 21 moves past the pin hole or other narrow slit 36 in the sound recording camera, continuously at a uniform speed, usually about one foot per second, that is, at the mean speed of the moving picture camera film. It will be understood that the film section 19 is covered and screened from the light over the entire section except that part of the film which is opposite the usual picture aperture or window, and that film section 21 is likewise covered or screened by screen 35 except the small part opposite the aperature 36, and that the film in passing across the said screen 35 is held in such close proximity thereto by the feeding mechanism, or otherwise, that the light rays passing through the aperature 36 will act only on the film area limited by the size of said aperture.

Specifically, the sound waves entering the horn 41 from a distant point are concentrated upon the diaphragm of the microphonic transmitter 40, forcibly vibrating the same to vary the resistance of the primary circuit, containing the battery B and the primary coil 43. The latter induces undulating or alternating currents of high tension corresponding in form and frequency with the sound waves impinging upon the diaphragm, in the secondary coil 44, which currents pass across the condenser 45, and become superposed upon the steady current flowing through the lamp 31 from the dynamo or other source 46. The direct current from the source 46, it will be seen, cannot jump across the condenser 45, nor affect the induction coil 43, so that the net result of the variable current impressed upon the lamp 31 by the action of the transmitter 40 will be alternately and rapidly to increase and decrease the intensity of the light in exact accordance with the original sound waves. More particularly, induction coil 43—44 inducing currents flowing alternately in opposite directions through the lamp filament, as the microphone resistance alternately increases and decreases, those currents that flow with the normal lamp current serve to reinforce it and augment the candle power, while those that flow against the normal lamp current oppose it and cause a diminution of the normal luminosity.

The light from the lamp 31 passes into the tube 32 and impinges upon the spherical lens 33, which effectively concentrates or focuses the light upon the screen 35 so that the light passing through the fixed minute aperture 36 will act uniformly over the area of the film exposed by the aperture. The light from the lamp is thus effectively concentrated at any instant upon the relatively minute film areas momentarily exposed. Since, moreover, both the candle power and the actinic effect of the ordinary tungsten or other equivalent lamp operating at rated current consumption, change markedly with small increments or decrements of current, it follows that the degree of exposure of the film will very relatively widely with the relatively minute changes in lamp current, taking place synchronously with and proportionally to the varying amplitudes of sound or air vibration.

In other words, by the use of a small lamp of low power consumption, operating at high incandescence, I produce maximum variations in candle power with the small increments or decrements of current due to the action of the air or sound waves upon the microphone. These variations in candle power are, moreover, intensified with respect to the film by efficiently focusing the light from the lamp at the highly restricted definitely limited momentarily exposed area of the film.

It will be seen that the tungsten lamp operates silently, eliminating the humming due to the rapid expansion and contraction of the heated gas, such as produced in an arc lamp flame.

When developed the translucency of the sound record produced on the film, operated at the speed noted with the momentary exposure limited to the width of the slit or small pin hole opening, changes rapidly from moment to moment, with the density or attenuation of the successive fractions of sound waves, which are recorded seriatim, without objectionable blurring or overlapping. In Fig. 8 is shown on a greatly enlarged scale, the approximate appearance of a small segment of a sound record, which may represent a portion of a single sound wave. The sound record, it is seen, presents a substantially straight band made up of a succession of lights and shadows, in which the alternations of light and shade and the distance between them correspond with and represent the wave length, pitch or frequency of the original sound waves, while the degree of differentiation in translucency between lighter and darker areas corresponds to and represents amplitudes or loudness. The darker and lighter areas of the band will usually merge into one another in a continuous succession in the direction of the length of the film. The translucency at each point on the band representing the momentary amplitude of air vibration, it will be seen that the simplest, as well as the most complex sound waves will be accurately recorded. The picture and voice sections 19 and 21 of the film, are simultaneously exposed at their respective optical centers, as heretofore noted, with the latter somewhat in advance of the former. This apparent displacement will be automatically neutralized, and the voice and picture recorded simultaneously if the time interval between the picture and voice sections substantially equals that for the travel of the sonorous action from a distant source to the receiving horn 41. The length of loop 20 in the camera may be adjusted in the camera and the voice transmitted from the horn to the camera electrically, in which case, the voice record will, of course, be impressed upon the film, with a lead relative to the corresponding picture.

In reproducing from the positive print of the negative film just described, the voice would be electrically transmitted from the projecting machine to the stage, and there telephonically reconverted into sound, with a lead relative to the corresponding picture, to compensate for the lag of sound relative to light, so that the visible and sonorous reproduction would reach the audience synchronously.

If desired, I may employ in lieu of the incandescent lamp, an arc lamp operated by direct current and burning with a steady light and at approximately constant temperature and luminosity. The variation in the current supply produced by sound vibrations directed upon the microphone connected in substantially the manner shown in the drawings, produces rapid variations in the candle power of the light, according to the singing or speaking arc principle. The arc lamp is preferably enclosed in a sound proof casing, so that the otherwise audible air vibrations set up thereby will not be heard.

It will be seen that whether the incandescent filament or arc lamp is employed, I produce undulatory variations in light intensity or candle power, similar in form to the vibrations of the air accompanying the vocal or other sonorous action, the varying light producing chemically a corresponding sound record upon the film, preferably taken concurrently with a record of the series of pictures of the scene. The film is developed to form a photographic negative and the combined picture and sound record may subsequently be transferred by photo-printing in the usual manner upon any desired number of positive films, from which the action is reproduced by a projection method and machine fully described in my copending parent application, heretofore mentioned.

It may be noted here that in the reproduction of my photographic sound record, the sound is in every respect identical whether it is reproduced from a negative or a positive print that is to say, that whereas in the negative the sound waves appear as light and dark sections or waves, corresponding sections or waves in the positive print will appear as dark and light, respectively, but the effect when projecting a beam of light through the film in either case to reproduce the sound waves recorded thereon will be the same.

In Figs. 6 to 7, I have illustratively shown

sound record, indicated by the numeral 50, extends or runs in a vertical direction at one side of the film, a space being reserved for this record between the right-hand sprocket perforations 51 on that side of the film, and the edge portion of the series of pictures 52 nearest thereto.

Fig. 5 shows an extra wide film, such as I prefer to use in taking and reproducing dramatic or operatic performances, on a large scale, in which the entire stage, either with or without its proscenium arch as a frame for the setting may be shown. This film also has an extra wide space 53 for my sound record, produced as with the aperture cap shown in Fig. 2, in order to give it ample capacity for the reception and proper reproduction of the powerful sound vibrations of a large chorus and orchestra.

In Fig. 6 the pictures 54 are shown as running horizontally, and the sound record 55 as extending in a horizontal direction below the same. The purpose of this arrangement is to eliminate, or at least in a large degree to minimize, the objectionable flickering of the ordinary film and the reduction of illumination caused by the use of a shutter, without hampering the recording or reproduction of the sound record.

The film 56 of Fig. 7 is provided with a plurality of sound records, two of these 57 and 58 being here shown as extending along the edges of the film outside of the left and right hand sprocket holes 59 respectively. This embodiment permits the use of the existing standard size of motion-picture films without diminution of the size of the pictures, and also permits the impression of one or more photographic sound records upon those portions of the film not at present utilized for photographic purposes. In the embodiment of Fig. 7, it will be understood that two or more sound records, both related to the picture are simultaneously recorded upon the film for alternate or concurrent reproduction. The method of producing the film or record will be apparent from the following illustrative example.

Let the animated pictures 56 shown in Fig. 7 represent the theme of an "illustrated song" pertaining to the sea, to be reproduced alternatively as desired, either with combined vocal and musical accompaniment, or with musical accompaniment alone. In recording, the vocalist, who in this instance does not appear in the picture, sings into my transmitter, preferably at close range and with the proper piano accompaniment, the verses appropriate to the theme, all of which is impressed to form say the right-hand sound record 58 of the film in the manner apparent from Fig. 1 of the [illegible]

voice is concurrently impressed on the opposite edge 57 of the film to form the left-hand record, by means of a second separate and independent transmitter and recording light-beam (not shown) similar to that described and shown. This accompaniment may be that of another instrument, as a violin played in a room partitioned off and in sound insulated relation from that occupied by the vocalist or piano, or it may be that of the identical piano which accompanies the vocalist. In the latter case, the second transmitter may be placed within the sound box of the piano, where it will not be affected by the voice of the singer.

Another application is to multiple language demonstration films, in which a single picture is accompanied by a plurality of sound records, explaining the action in various languages. The film is produced in a manner analogous to that just described, the lectures in the various languages being recorded simultaneously with the picture, but independently on different bands of the same film.

Although I have herein shown and described my invention more particularly in connection with kinetoscopic or cinematographic films, I desire it to be understood that many of the features of my method are applicable to the production of one or more photographic records of vocal, musical or other sonorous action, independently of pictures.

My method, as herein disclosed, is not limited to the particular applications thereof, which I have illustrated in the drawings, but is broadly as well as specifically aplicable to numerous other purposes and capable of being carried out in various forms of phonographic, telephonic and other apparatus.

Having thus described my invention what I claim as new and desire to secure by Letters Patent of the United States is:—

1. The method of recording sound photographically, which consists in moving a body having a surface sensitive to light across the back of a screen having a small aperture, limiting the area of exposure to the area of the aperture, and varying the degree of exposure in accordance with sound waves impressed upon a sound translating device, whereby said sensitized surface when developed will present a continuous line or band having alternating sections of varying degrees of density or translucency throughout its length, the opposite extremes of density indicating the peaks of continuous waves corresponding to the sound waves impressed upon the sound translating device.

2. The method of recording sound pho-

In other words, by the use of a small lamp of low power consumption, operating at high incandescence, I produce maximum variations in candle power with the small increments or decrements of current due to the action of the air or sound waves upon the microphone. These variations in candle power are, moreover, intensified with respect to the film by efficiently focusing the light from the lamp at the highly restricted definitely limited momentarily exposed area of the film.

It will be seen that the tungsten lamp operates silently, eliminating the humming due to the rapid expansion and contraction of the heated gas, such as produced in an arc lamp flame.

When developed the translucency of the sound record produced on the film, operated at the speed noted with the momentary exposure limited to the width of the slit or small pin hole opening, changes rapidly from moment to moment, with the density or attenuation of the successive fractions of sound waves, which are recorded seriatim, without objectionable blurring or overlapping. In Fig. 8 is shown on a greatly enlarged scale, the approximate appearance of a small segment of a sound record, which may represent a portion of a single sound wave. The sound record, it is seen, presents a substantially straight band made up of a succession of lights and shadows, in which the alternations of light and shade and the distance between them correspond with and represent the wave length, pitch or frequency of the original sound waves, while the degree of differentiation in translucency between lighter and darker areas corresponds to and represents amplitudes or loudness. The darker and lighter areas of the band will usually merge into one another in a continuous succession in the direction of the length of the film. The translucency at each point on the band representing the momentary amplitude of air vibration, it will be seen that the simplest, as well as the most complex sound waves will be accurately recorded. The picture and voice sections 19 and 21 of the film, are simultaneously exposed at their respective optical centers, as heretofore noted, with the latter somewhat in advance of the former. This apparent displacement will be automatically neutralized, and the voice and picture recorded simultaneously if the time interval between the picture and voice sections substantially equals that for the travel of the sonorous action from a distant source to the receiving horn 41. The length of loop 20 in the camera may be adjusted in accordance with the distance of the stage or other source of sound from the camera.

The receiving horn 41, it will be understood, may be placed nearer the stage than the camera and the voice transmitted from the horn to the camera electrically, in which case, the voice record will, of course, be impressed upon the film, with a lead relative to the corresponding picture.

In reproducing from the positive print of the negative film just described, the voice would be electrically transmitted from the projecting machine to the stage, and there telephonically reconverted into sound, with a lead relative to the corresponding picture, to compensate for the lag of sound relative to light, so that the visible and sonorous reproduction would reach the audience synchronously.

If desired, I may employ in lieu of the incandescent lamp, an arc lamp operated by direct current and burning with a steady light and at approximately constant temperature and luminosity. The variation in the current supply produced by sound vibrations directed upon the microphone connected in substantially the manner shown in the drawings, produces rapid variations in the candle power of the light, according to the singing or speaking arc principle. The arc lamp is preferably enclosed in a sound proof casing, so that the otherwise audible air vibrations set up thereby will not be heard.

It will be seen that whether the incandescent filament or arc lamp is employed, I produce undulatory variations in light intensity or candle power, similar in form to the vibrations of the air accompanying the vocal or other sonorous action, the varying light producing chemically a corresponding sound record upon the film, preferably taken concurrently with a record of the series of pictures of the scene. The film is developed to form a photographic negative and the combined picture and sound record may subsequently be transferred by photo-printing in the usual manner upon any desired number of positive films, from which the action is reproduced by a projection method and machine fully described in my copending parent application, heretofore mentioned.

It may be noted here that in the reproduction of my photographic sound record, the sound is in every respect identical whether it is reproduced from a negative or a positive print that is to say, that whereas in the negative the sound waves appear as light and dark sections or waves, corresponding sections or waves in the positive print will appear as dark and light, respectively, but the effect when projecting a beam of light through the film in either case to reproduce the sound waves recorded thereon will be the same.

In Figs. 4 to 7, I have illustratively shown various typical forms of "phonoscopic" or talking machine films produced by my method. In the embodiment of Fig. 4, the

extends or runs in a vertical direction at one side of the film, a space being reserved for this record between the right-hand sprocket perforations 51 on that side of the film, and the edge portion of the series of pictures 52 nearest thereto.

Fig. 5 shows an extra wide film, such as I prefer to use in taking and reproducing dramatic or operatic performances, on a large scale, in which the entire stage, either with or without its proscenium arch as a frame for the setting may be shown. This film also has an extra wide space 53 for my sound record, produced as with the aperture cap shown in Fig. 2, in order to give it ample capacity for the reception and proper reproduction of the powerful sound vibrations of a large chorus and orchestra.

In Fig. 6 the pictures 54 are shown as running horizontally, and the sound record 55 as extending in a horizontal direction below the same. The purpose of this arrangement is to eliminate, or at least in a large degree to minimize, the objectionable flickering of the ordinary film and the reduction of illumination caused by the use of a shutter, without hampering the recording or reproduction of the sound record.

The film 56 of Fig. 7 is provided with a plurality of sound records, two of these 57 and 58 being here shown as extending along the edges of the film outside of the left and right hand sprocket holes 59 respectively. This embodiment permits the use of the existing standard size of motion-picture films without diminution of the size of the pictures, and also permits the impression of one or more photographic sound records upon those portions of the film not at present utilized for photographic purposes. In the embodiment of Fig. 7, it will be understood that two or more sound records, both related to the picture are simultaneously recorded upon the film for alternate or concurrent reproduction. The method of producing the film or record will be apparent from the following illustrative example.

Let the animated pictures 56 shown in Fig. 7 represent the theme of an "illustrated song" pertaining to the sea, to be reproduced alternatively as desired, either with combined vocal and musical accompaniment, or with musical accompaniment alone. In recording, the vocalist, who in this instance does not appear in the picture, sings into my transmitter, preferably at close range and with the proper piano accompaniment, the verses appropriate to the theme, all of which is impressed to form say the right-hand sound record 58 of the film in the manner apparent from Fig. 1 of the drawings and the previous description. The musical accompaniment only, minus the posite edge 57 of the film to form the left-hand record, by means of a second separate and independent transmitter and recording light-beam (not shown) similar to that described and shown. This accompaniment may be that of another instrument, as a violin played in a room partitioned off and in sound insulated relation from that occupied by the vocalist or piano, or it may be that of the identical piano which accompanies the vocalist. In the latter case, the second transmitter may be placed within the sound box of the piano, where it will not be affected by the voice of the singer.

Another application is to multiple language demonstration films, in which a single picture is accompanied by a plurality of sound records, explaining the action in various languages. The film is produced in a manner analogous to that just described, the lectures in the various languages being recorded simultaneously with the picture, but independently on different bands of the same film.

Although I have herein shown and described my invention more particularly in connection with kinetoscopic or cinematographic films, I desire it to be understood that many of the features of my method are applicable to the production of one or more photographic records of vocal, musical or other sonorous action, independently of pictures.

My method, as herein disclosed, is not limited to the particular applications thereof, which I have illustrated in the drawings, but is broadly as well as specifically aplicable to numerous other purposes and capable of being carried out in various forms of phonographic, telephonic and other apparatus.

Having thus described my invention what I claim as new and desire to secure by Letters Patent of the United States is:—

1. The method of recording sound photographically, which consists in moving a body having a surface sensitive to light across the back of a screen having a small aperture, limiting the area of exposure to the area of the aperture, and varying the degree of exposure in accordance with sound waves impressed upon a sound translating device, whereby said sensitized surface when developed will present a continuous line or band having alternating sections of varying degrees of density or translucency throughout its length, the opposite extremes of density indicating the peaks of continuous waves corresponding to the sound waves impressed upon the sound translating device.

2. The method of recording sound photographically, which consists in moving a body having a surface sensitive to light across the back of a screen having a small

aperture which exposes the sensitive material to light in a continuous line or band of uniform width, limiting the area of exposure to the area of the aperture, and varying the intensity of the light in accordance with sound waves impressed upon a sound transmitting device for the purpose of producing corresponding variations in the degree of exposure of said sensitive material as the same is moved across the aperture.

3. The method of recording sound photographically, which consists in moving at a constant speed a body having a surface sensitive to light across the back of a screen having a small aperture which exposes the sensitive material to light in a continuous line or band of uniform width, limiting the area of exposure to the area of the aperture, and varying the intensity of the light in accordance with sound waves impressed upon a sound transmitting device for the purpose of producing corresponding variations in the degree of exposure of said sensitive surface as the same is moved across the aperture.

4. The method of recording sound photographically, which consists in moving a photographic film in the form of a strip or band across the back of a screen having a narrow aperture which exposes the sensitive material to light in a continuous line or band of uniform width throughout the length of the film, limiting the area of exposure to the area of the aperture, and varying the degree of exposure of said line or band in accordance with sound waves impressed upon a sound translating device, whereby said film when developed will present a continuous line or band of uniform width and alternating sections of varying degrees of density or translucency throughout its length, the opposite extremes of density indicating the peaks of continuous waves corresponding to the sound waves impressed upon the sound translating device.

5. The method of recording sound photographically, which consists in moving a photographic film in the form of a strip or band across the back of a screen having a narrow aperture which exposes the sensitive material to light in a continuous line or band of uniform width throughout the length of the film, limiting the area of exposure to the area of the aperture, and varying the intensity of the light by and in accordance with sound waves impressed upon a sound transmitting device for the purpose of producing corresponding variations in the degree of exposure of said sensitive material as the same is moved across the and varying degrees of density or translucency throughout its length corresponding to the variations in light produced by the sound waves impressed upon the sound transmitting device.

6. The method of recording sound photographically, which consists in moving at a constant speed a photographic film in the form of a strip or band across the back of a screen having a narrow aperture which exposes the sensitive material to light in a continuous line or band of uniform width throughout the length of the film, limiting the area of exposure to the area of the aperture, and varying the intensity of the light by and in accordance with sound waves impressed upon a sound transmitting device for the purpose of producing corresponding variations in the degree of exposure of said sensitive material as the same is moved across the narrow aperture, whereby when the film is developed a record is produced on said photographic film in the form of a continuous line or band of uniform width and having alternating sections of varying degrees of density or translucency throughout its length, the opposite extremes of density indicating the peaks of continuous waves corresponding to the variations in light produced by the sound waves impressed upon the sound transmitting device.

7. The method of recording sonorous action by causing undulatory variations in light intensity, similar in form to the vibrations of the air accompanying the said action, and exposing a photographic film to the influence of the light only through a window aperture of the width of a small pin hole adjacent the film, while moving the film at a speed in the order of one foot per second to effect an imprint thereon lengthwise of the film, differentiated in accordance with the varying amplitudes of sound vibrations and limiting the area of exposure to the area of the aperture.

8. The method of recording sonorous action by causing undulatory variations in light intensity, similar in form to the vibrations of the air accompanying the said action, focusing the light in a pointed pencil toward a fixed point substantially in the plane of a photographic film moving at a rate of speed in the order of one foot per second, and through a window aperture adjacent the film, of substantially the width of a small pin hole and limiting the area of exposure to the area of the aperture.

9. The method of concurrently recording simultaneous visible and sonorous action upon a single photographic film, which consists in focusing the visible action upon the

and at a strip thereof laterally of the picture portion and at a region where the film moves at constant speed, and screening the film in the path of the variable light to expose an area limited in width in the direction of the moving film to the width of a small pin hole, said light having undulatory variations in intensity similar in form to the vibrations of the air accompanying the sonorous action.

10. The method of recording sound waves upon a traveling photographic film limited in speed to motion picture requirements, which consists of photographing thereon the denser and more attenuated portions thereof seriatim, the period of photographic exposure being so related to the speed of the film and to the duration of said portions of sound waves as to prevent overlapping or blurring, accomplished by varying the intensity of a beam of light in accordance with the varying amplitudes and phases of said waves, having said beam narrowed by a slit to adjust the period of exposure to the speed of the film and the duration of the parts of sound waves and limiting the area of exposure to the area of the slit.

11. The method of recording sound waves upon a traveling photographic film limited in speed to motion picture requirements, which consists of photographing thereon the denser and more attenuated portions thereof seriatim, the period of photographic exposure being so related to the speed of the film and to the duration of said portions of sound waves as to prevent overlapping or blurring, accomplished by varying the intensity of a beam of light in accordance with the varying amplitudes and phases of said waves, assisted by focusing said beam on said film through a slit to further define the characteristics of the shorter waves and limiting the area of exposure to the area of the slit.

12. The method of recording sound photographically, which consists in moving a photographic film in the form of a strip or band across an aperture plate, limiting the exposed area of the film to the area of the aperture by maintaining the film in close contact with said plate, moving the film at a constant speed across said aperture to expose the sensitive surface to light in a continuous line or band of uniform width, and varying the degree of exposure of said line or band in accordance with sound waves impressed upon a sound translating device, whereby said sensitized surface when developed will present a continuous line or band of uniform width and alternating sections of varying degrees of density or translucency representing continuous waves corresponding to the sound waves impressed

photographic film in the form of a strip or band across an aperture plate, limiting the exposed area of the sensitive surface to a space of the order of a thin line by an aperture in said plate whose width is much greater than its length, maintaining the film in close contact with said plate to prevent diffusion of light, moving the film at a constant speed across said aperture to expose the sensitive surface to light in a continuous line or band of uniform width, and varying the degree of exposure of said line or band in accordance with sound waves impressed upon a sound translating device, whereby said sensitized surface when developed will present a continuous line or band of uniform width and alternating sections of varying degrees of density or translucency representing continuous waves corresponding to the sound waves impressed upon the sound translating device.

14. The method of producing motion pictures and photographic sound records concurrently upon the same photographic film, which consists in moving a photographic film through a camera at a speed adapted to produce a given number of pictures per second, simultaneously moving said film at the same rate per second across the back of a screen having a narrow aperture which exposes the sensitized surface to light in a continuous line or band parallel to the line of pictures and of uniform width throughout its length, limiting the area of exposure to the area of the aperture, and varying the degree of exposure of said line or band in accordance with sound waves impressed upon a sound translating device, whereby said sensitive surface when developed will present adjacent to the pictures a continuous line or band of uniform width and having alternating sections of varying degrees of density or translucency representing continuous waves corresponding to the sound waves impressed upon the sound translating device.

15. The method of producing motion pictures and photographic sound records concurrently upon the same photographic film, which consists in moving a photographic film through a camera at a speed adapted to produce a given number of pictures per second, simultaneously moving said film at the same rate per second across the back of a screen having two narrow apertures by which the sensitized surface is exposed to light in two continuous lines or bands parallel to the line of pictures, and each band being of uniform width throughout its length, limiting the areas of exposure of each band to the areas of the respective apertures

aperture which exposes the sensitive material to light in a continuous line or band of uniform width, limiting the area of exposure to the area of the aperture, and varying the intensity of the light in accordance with sound waves impressed upon a sound transmitting device for the purpose of producing corresponding variations in the degree of exposure of said sensitive material as the same is moved across the aperture.

3. The method of recording sound photographically, which consists in moving at a constant speed a body having a surface sensitive to light across the back of a screen having a small aperture which exposes the sensitive material to light in a continuous line or band of uniform width, limiting the area of exposure to the area of the aperture, and varying the intensity of the light in accordance with sound waves impressed upon a sound transmitting device for the purpose of producing corresponding variations in the degree of exposure of said sensitive surface as the same is moved across the aperture.

4. The method of recording sound photographically, which consists in moving a photographic film in the form of a strip or band across the back of a screen having a narrow aperture which exposes the sensitive material to light in a continuous line or band of uniform width throughout the length of the film, limiting the area of exposure to the area of the aperture, and varying the degree of exposure of said line or band in accordance with sound waves impressed upon a sound translating device, whereby said film when developed will present a continuous line or band of uniform width and alternating sections of varying degrees of density or translucency throughout its length, the opposite extremes of density indicating the peaks of continuous waves corresponding to the sound waves impressed upon the sound translating device.

5. The method of recording sound photographically, which consists in moving a photographic film in the form of a strip or band across the back of a screen having a narrow aperture which exposes the sensitive material to light in a continuous line or band of uniform width throughout the length of the film, limiting the area of exposure to the area of the aperture, and varying the intensity of the light by and in accordance with sound waves impressed upon a sound transmitting device for the purpose of producing corresponding variations in the degree of exposure of said sensitive material as the same is moved across the narrow aperture, whereby when the film is developed a record is produced on said photographic film in the form of a continuous line of band of uniform width and varying degrees of density or translucency throughout its length corresponding to the variations in light produced by the sound waves impressed upon the sound transmitting device.

6. The method of recording sound photographically, which consists in moving at a constant speed a photographic film in the form of a strip or band across the back of a screen having a narrow aperture which exposes the sensitive material to light in a continuous line or band of uniform width throughout the length of the film, limiting the area of exposure to the area of the aperture, and varying the intensity of the light by and in accordance with sound waves impressed upon a sound transmitting device for the purpose of producing corresponding variations in the degree of exposure of said sensitive material as the same is moved across the narrow aperture, whereby when the film is developed a record is produced on said photographic film in the form of a continuous line or band of uniform width and having alternating sections of varying degrees of density or translucency throughout its length, the opposite extremes of density indicating the peaks of continuous waves corresponding to the variations in light produced by the sound waves impressed upon the sound transmitting device.

7. The method of recording sonorous action by causing undulatory variations in light intensity, similar in form to the vibrations of the air accompanying the said action, and exposing a photographic film to the influence of the light only through a window aperture of the width of a small pin hole adjacent the film, while moving the film at a speed in the order of one foot per second to effect an imprint thereon lengthwise of the film, differentiated in accordance with the varying amplitudes of sound vibrations and limiting the area of exposure to the area of the aperture.

8. The method of recording sonorous action by causing undulatory variations in light intensity, similar in form to the vibrations of the air accompanying the said action, focusing the light in a pointed pencil toward a fixed point substantially in the plane of a photographic film moving at a rate of speed in the order of one foot per second, and through a window aperture adjacent the film, of substantially the width of a small pin hole and limiting the area of exposure to the area of the aperture.

9. The method of concurrently recording simultaneous visible and sonorous action upon a single photographic film, which consists in focusing the visible action upon the film during intermittent advance thereof at said focusing region, while focusing light directed in a pointed pencil toward a fixed point substantially in the plane of the film

and at a strip thereof laterally of the picture portion and at a region where the film moves at constant speed, and screening the film in the path of the variable light to expose an area limited in width in the direction of the moving film to the width of a small pin hole, said light having undulatory variations in intensity similar in form to the vibrations of the air accompanying the sonorous action.

10. The method of recording sound waves upon a traveling photographic film limited in speed to motion picture requirements, which consists of photographing thereon the denser and more attenuated portions thereof seriatim, the period of photographic exposure being so related to the speed of the film and to the duration of said portions of sound waves as to prevent overlapping or blurring, accomplished by varying the intensity of a beam of light in accordance with the varying amplitudes and phases of said waves, having said beam narrowed by a slit to adjust the period of exposure to the speed of the film and the duration of the parts of sound waves and limiting the area of exposure to the area of the slit.

11. The method of recording sound waves upon a traveling photographic film limited in speed to motion picture requirements, which consists of photographing thereon the denser and more attenuated portions thereof seriatim, the period of photographic exposure being so related to the speed of the film and to the duration of said portions of sound waves as to prevent overlapping or blurring, accomplished by varying the intensity of a beam of light in accordance with the varying amplitudes and phases of said waves, assisted by focusing said beam on said film through a slit to further define the characteristics of the shorter waves and limiting the area of exposure to the area of the slit.

12. The method of recording sound photographically, which consists in moving a photographic film in the form of a strip or band across an aperture plate, limiting the exposed area of the film to the area of the aperture by maintaining the film in close contact with said plate, moving the film at a constant speed across said aperture to expose the sensitive surface to light in a continuous line or band of uniform width, and varying the degree of exposure of said line or band in accordance with sound waves impressed upon a sound translating device, whereby said sensitized surface when developed will present a continuous line or band of uniform width and alternating sections of varying degrees of density or translucency representing continuous waves corresponding to the sound waves impressed upon the sound translating device.

13. The method of recording sound photographically, which consists in moving a photographic film in the form of a strip or band across an aperture plate, limiting the exposed area of the sensitive surface to a space of the order of a thin line by an aperture in said plate whose width is much greater than its length, maintaining the film in close contact with said plate to prevent diffusion of light, moving the film at a constant speed across said aperture to expose the sensitive surface to light in a continuous line or band of uniform width, and varying the degree of exposure of said line or band in accordance with sound waves impressed upon a sound translating device, whereby said sensitized surface when developed will present a continuous line or band of uniform width and alternating sections of varying degrees of density or translucency representing continuous waves corresponding to the sound waves impressed upon the sound translating device.

14. The method of producing motion pictures and photographic sound records concurrently upon the same photographic film, which consists in moving a photographic film through a camera at a speed adapted to produce a given number of pictures per second, simultaneously moving said film at the same rate per second across the back of a screen having a narrow aperture which exposes the sensitized surface to light in a continuous line or band parallel to the line of pictures and of uniform width throughout its length, limiting the area of exposure to the area of the aperture, and varying the degree of exposure of said line or band in accordance with sound waves impressed upon a sound translating device, whereby said sensitive surface when developed will present adjacent to the pictures a continuous line or band of uniform width and having alternating sections of varying degrees of density or translucency representing continuous waves corresponding to the sound waves impressed upon the sound translating device.

15. The method of producing motion pictures and photographic sound records concurrently upon the same photographic film, which consists in moving a photographic film through a camera at a speed adapted to produce a given number of pictures per second, simultaneously moving said film at the same rate per second across the back of a screen having two narrow apertures by which the sensitized surface is exposed to light in two continuous lines or bands parallel to the line of pictures, and each band being of uniform width throughout its length, limiting the areas of exposure of each band to the areas of the respective apertures and varying the degree of exposure of said lines or bands by and in accordance with sound waves impressed upon a sound transmitting device, whereby said sensitized sur-

face when developed will present adjacent to the pictures two bands each of uniform width throughout and having alternating sections of varying degrees of density or translucency representing continuous waves corresponding to the sound waves impressed upon the sound transmitting device.

16. The method of producing motion pictures and photographic sound records concurrently upon the same photographic film, which consists in moving a photographic film through a camera at a speed of approximately one linear foot per second, simultaneously moving said film at the same rate of speed across the back of a screen having a narrow aperture which exposes the sensitized surface to light in a continuous line or band parallel to the line of pictures and of uniform width throughout its length, limiting the area of exposure to the area of the aperture, and varying the intensity of the light by and in accordance with sound waves impressed upon a sound transmitting device for the purpose of producing corresponding variations in the degree of exposure of said sensitized surface as the same is moved across the narrow aperture, whereby said sensitized surface when developed will present adjacent to the pictures a continuous line or band of uniform width and having alternating sections of varying degrees of density or translucency representing continuous waves corresponding to the sound waves impressed upon the sound transmitting device.

17. The method of producing motion pictures and photographic sound records concurrently upon the same photographic film, which consists in intermittently moving a photographic film through a camera at a speed adapted to produce a given number of pictures per second, simultaneously moving said film continuously and uniformly at the same rate per second across the back of a screen having a narrow aperture which exposes the sensitized surface to light in a continuous line or band parallel to the line of pictures and of uniform width throughout its length, limiting the area of exposure to the area of the aperture, and varying the degree of exposure of said line or band in accordance with sound waves impressed upon a sound translating device, whereby said sensitized surface when developed will present adjacent to the pictures a continuous line or band of uniform width and having alternating sections of varying degrees of density or translucency representing continuous waves corresponding to the sound waves impressed upon the sound translating device.

18. The method of producing motion pictures and photographic sound records concurrently upon the same photographic film, which consists in intermittently moving a photographic film through a camera at a speed of approximately one linear foot per second, simultaneously moving said film continuously and uniformly at the same rate of speed across the back of a screen having a narrow aperture which exposes the sensitized surface to light in a continuous line or band parallel to the line of pictures and of uniform width throughout its length, limiting the area of exposure to the area of the aperture, and varying the intensity of the light by and in accordance with sound waves impressed upon a sound transmitting device for the purpose of producing corresponding variations in the degree of exposure of said sensitized surface as the same is moved across the narrow aperture, whereby said sensitized surface when developed will present adjacent to the pictures a continuous line or band of uniform width and having alternating sections of varying degrees of density or translucency representing continuous waves corresponding to the sound waves impressed upon the sound transmitting device.

19. The method of producing motion pictures and photographic sound records concurrently upon the same photographic film, which consists in intermittently moving a photographic film at a speed of approximately one linear foot per second through a camera having a lens for taking a series of pictures in single line sequence representing objects in motion, simultaneously moving said film continuously and uniformly at the same rate of speed across the back of a screen having two narrow apertures by which the sensitized surface is exposed to light in two continuous lines or bands parallel to the line of pictures, and each band being of uniform width throughout its length, limiting the areas of exposure of each band to the areas of the respective apertures, and varying the degree of exposure of said lines or bands by and in accordance with sound waves impressed upon sound transmitting devices, whereby said sensitized surface when developed will present adjacent to the pictures two bands each of uniform width throughout and having alternating sections of varying degrees of density or translucency representing continuous waves corresponding to the sound waves impressed upon the sound transmitting devices.

Signed at New York city, in the county of New York and State of New York, this 5th day of April, 1923.

ELIAS E. RIES.

1228

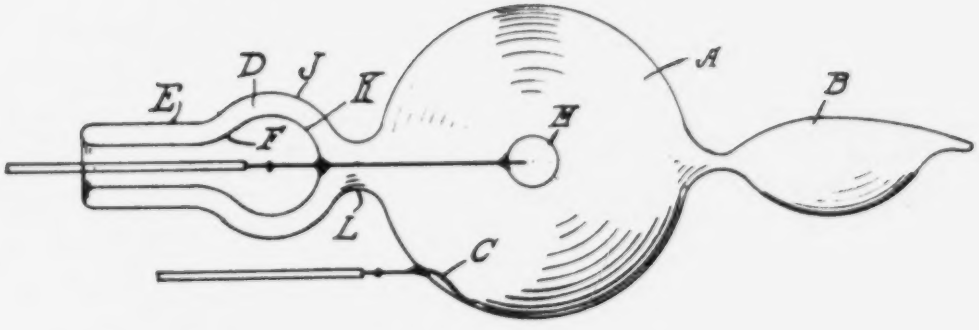
Dec. 29 1925

1,567,424

A. H. COMPTON

PHOTO ELECTRIC CELL

Filed March 1, 1921



Inventor
ARTHUR H. COMPTON

By his Attorney
Charles E. Carr

Patented Dec. 29, 1925. 1,567,424

UNITED STATES PATENT OFFICE.

ARTHUR H. COMPTON, OF ST. LOUIS, MISSOURI, ASSIGNOR TO WESTINGHOUSE LAMP COMPANY, A CORPORATION OF PENNSYLVANIA.

PHOTO-ELECTRIC CELL.

Application filed March 1, 1921. Serial No. 448,944.

To all whom it may concern:

Be it known that I, ARTHUR H. COMPTON, a citizen of the United States, and a resident of St. Louis, in the State of Missouri, have invented a new and useful Improvement in Photo-Electric Cells, of which the following is a specification.

My invention relates to photoelectric cells and has more particular relation to the production of an alkali-metal cell in which the light-sensitive alkali metal, for example, potassium, is evenly distributed over, and in intimate contact with, a limited portion of an evacuated-cell envelope.

In order to secure this even distribution and intimate contact, it is desirable to employ a deposition method, for example, the condensation of a light-sensitive material in gaseous or vapor form. In alkali-metal cells it is essential, however, that a portion of the dielectric envelope between the electrodes shall be preserved free from metal deposit. The limitation of the deposit to a portion of the cell envelope and the preservation of some portion of the cell envelope between the electrodes free from deposited metal is the primary object of this invention.

One way in which this object may be obtained is by providing a structure, as shown in the accompanying drawing, having an auxiliary tube, preferably located around the leading-in conductor to one of the electrodes and communicating with the cell envelope proper. This tube is provided with an irregular or sinuous channel at some portion thereof, the sinuosities of the channel providing a partial barrier to intercept the volatilized light-responsive material and thereby preventing it from being deposited on some portion thereof. The result is that some portion of the cell envelope along which current might flow between the electrodes, is preserved free from deposited light-responsive material, while the remainder of the envelope is coated with such material adhering to the cell envelope.

In order to illustrate my invention I have shown one embodiment thereof in the accompanying drawing, in which a longitudinal section of the cell, partly diagrammatic, is shown.

rial, at least in sufficient quantity to adequately coat the desired portion of the wall or envelope of the chamber.

An electrode C is located on the inner face of the wall or envelope of chamber A and at any convenient point thereof. The electrode C may be, and preferably is, connected to a lead wire sealed in the wall of the chamber A in the usual manner. A double-wall side tube D is arranged to communicate with the chamber A and is preferably formed integrally therewith. Conveniently, the double-wall side tube D is located on the side of the chamber A opposite to the tube B, to preserve the symmetry of the arrangement. The tube D comprises an outer shell E and a reentrant fold F forming a crater-like tube the shell E and the fold F being spaced from each other and each provided with corresponding bulbous or swollen portions J and K, respectively. The space between the outer shell E and the reentrant fold F forms an annular pocket which communicates with the chamber A through the restricted neck L. The bulbous portions J and K provide sinuosities in the pocket, which constitute a barrier and thereby cause a condensation of the volatilized light-responsive material when it comes into contact with said sinuosities.

A second electrode M is located within the chamber A to receive its energy through a suitable lead wire which may, and preferably does, extend through the fold F of the side tube D, being sealed therein in the usual manner.

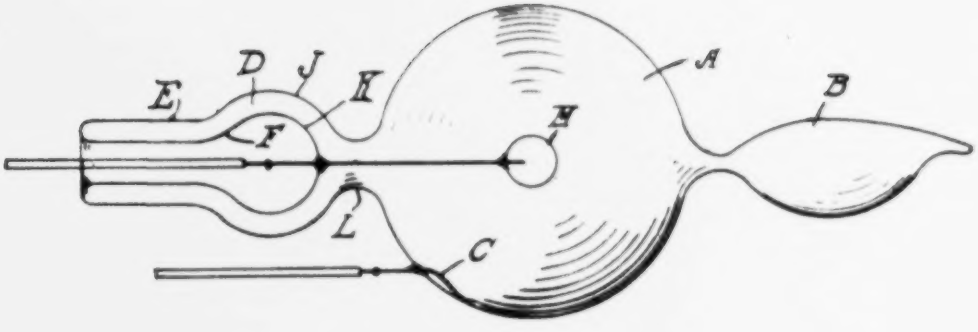
In preparing the cell for use, the alkali metal, specifically potassium, contained in the chamber B, is volatilized, the volatile material passing into chamber A and being condensed on the walls thereof in a substantially even layer having intimate contact with the wall of chamber A. The flow of the volatilized material into the annular irregular pocket formed in the side tube D is substantially prevented by the condensation of the material at the mouth of the pocket. The gaseous material is directed in substantially straight lines from the mouth of the chamber B and the small amount thereof entering the restricted neck

Dec. 29 1925 1,567,424

A. H. COMPTON

PHOTO ELECTRIC CELL

Filed March 1, 1921



Inventor
ARTHUR H. COMPTON

By his Attorney
Chesley G. Carr

UNITED STATES PATENT OFFICE.

ARTHUR H. COMPTON, OF ST. LOUIS, MISSOURI, ASSIGNOR TO WESTINGHOUSE LAMP COMPANY, A CORPORATION OF PENNSYLVANIA.

PHOTO-ELECTRIC CELL.

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To all whom it may concern:

Be it known that I, ARTHUR H. COMPTON, a citizen of the United States, and a resident of St. Louis, in the State of Missouri, have invented a new and useful Improvement in Photo-Electric Cells, of which the following is a specification.

My invention relates to photoelectric cells and has more particular relation to the production of an alkali-metal cell in which the light-sensitive alkali metal, for example, potassium, is evenly distributed over, and in intimate contact with, a limited portion of an evacuated-cell envelope.

In order to secure this even distribution and intimate contact, it is desirable to employ a deposition method, for example, the condensation of a light-sensitive material in gaseous or vapor form. In alkali-metal cells it is essential, however, that a portion of the dielectric envelope between the electrodes shall be preserved free from metal deposit. The limitation of the deposit to a portion of the cell envelope and the preservation of some portion of the cell envelope between the electrodes free from deposited metal is the primary object of this invention.

One way in which this object may be obtained is by providing a structure, as shown in the accompanying drawing, having an auxiliary tube, preferably located around the leading-in conductor to one of the electrodes and communicating with the cell envelope proper. This tube is provided with an irregular or sinuous channel at some portion thereof, the sinuosities of the channel providing a partial barrier to intercept the volatilized light-responsive material and thereby preventing it from being deposited on some portion thereof. The result is that some portion of the cell envelope along which current might flow between the electrodes, is preserved free from deposited light-responsive material, while the remainder of the envelope is coated with such material adhering to the cell envelope.

In order to illustrate my invention I have shown one embodiment thereof in the accompanying drawing, in which a longitudinal section of the cell, partly diagrammatic, is shown.

An evacuated electrode-containing chamber A is preferably provided with a laterally-extending distilling tube or reservoir B adapted to contain light-responsive material, at least in sufficient quantity to adequately coat the desired portion of the wall or envelope of the chamber.

An electrode C is located on the inner face of the wall or envelope of chamber A and at any convenient point thereof. The electrode C may be, and preferably is, connected to a lead wire sealed in the wall of the chamber A in the usual manner. A double-wall side tube D is arranged to communicate with the chamber A and is preferably formed integrally therewith. Conveniently, the double-wall side tube D is located on the side of the chamber A opposite to the tube B, to preserve the symmetry of the arrangement. The tube D comprises an outer shell E and a reentrant fold F forming a crater-like tube the shell E and the fold F being spaced from each other and each provided with corresponding bulbous or swollen portions J and K, respectively. The space between the outer shell E and the reentrant fold F forms an annular pocket which communicates with the chamber A through the restricted neck L. The bulbous portions J and K provide sinuosities in the pocket, which constitute a barrier and thereby cause a condensation of the volatilized light-responsive material when it comes into contact with said sinuosities.

A second electrode M is located within the chamber A to receive its energy through a suitable lead wire which may, and preferably does, extend through the fold F of the side tube D, being sealed therein in the usual manner.

In preparing the cell for use, the alkali metal, specifically potassium, contained in the chamber B, is volatilized, the volatile material passing into chamber A and being condensed on the walls thereof in a substantially even layer having intimate contact with the wall of chamber A. The flow of the volatilized material into the annular irregular pocket formed in the side tube D is substantially prevented by the condensation of the material at the mouth of the pocket. The gaseous material is directed in substantially straight lines from the mouth of the chamber B and the small amount thereof entering the restricted neck portion L comes into contact with and is condensed upon the end of the enlarged portion of the reentrant fold F and thus is prevented from entering the reversely

curved annular passage between the outer shell E and the reentrant fold F.

It will be noted, that the electrode M is effectively insulated from the electrode C by a comparatively wide zone extending substantially from the equator of the enlargement K to the restricted portion L of the envelope. It should be further noted that there are two distinct shadow zones or portions protected from the vaporized material emanating from the chamber B, namely that portion of the outer wall of the shell E in the shadow of the restriction L and that portion of the reentrant fold forming the rear side of the enlargement K and in the shadow thereof.

Evidently, if a single bulbous region is insufficient to adequately intercept the volatilized material and prevent it from passing into the tube D, a plurality of such bulbous regions may be used.

Although I have found potassium and sodium to be particularly adapted for use in practicing my invention, rubidium and cæsium may also prove to be suitable light-responsive materials which may be screened in the same manner as potassium. Also, it may be found desirable to limit the deposited area in cells employing light-sensitive materials other than those mentioned. Hence, when I specify a light-sensitive material, I mean to include such materials, other than potassium, as may be found suitable.

What is claimed is:

1. A photo-electric cell comprising an envelope consisting of a main chamber and an auxiliary chamber connected by a restricted neck, said auxiliary chamber having a curved passage forming a plurality of shadow zones, an electrode extending through the wall of the auxiliary chamber and the neck into the main chamber and another electrode extending through the wall of the main chamber, light-sensitive material deposited on the wall of the main chamber, connected with the second electrode and insulated from the first electrode by said shadow zones.

2. A photo-electric cell comprising an envelope consisting of a main chamber and an auxiliary chamber of non-uniform cross section and connected to the main chamber by a restricted neck, an electrode extending through the wall of the auxiliary chamber and the neck into the main chamber, the interior of the wall of the main chamber substantially uniformly coated with a light-sensitive material insulated from the electrode and electrically connected to a leading-in wire extending through the wall of the main chamber.

3. A photo-electric cell comprising an envelope consisting of a main chamber and an auxiliary chamber having a reversely curved sinuous channel and connected to the main chamber by a restricted portion, an anode extending through the wall of the auxiliary chamber and the restricted portion into the main chamber and a cathode conductor extending through the wall of the main chamber and connected to the deposit of alkali metal on the interior of said wall, but insulated from the leading-in conductor of the anode by said sinuous channel.

4. A photo-electric cell comprising an envelope consisting of a main chamber and an auxiliary annular chamber having a reversely curved channel and connected to the main chamber by a restricted portion, an electrode in the main chamber and connected to a leading-in conductor extending through the restricted portion and the wall of the auxiliary chamber, another electrode extending through the wall of the main chamber and means for introducing alkali metal into the main chamber as a substantially uniform film on the wall thereof, without depositing it on the wall of the auxiliary chamber to a sufficient extent to form a short-circuiting path between the electrodes.

5. An envelope for an electric device comprising a main chamber and an annular auxiliary chamber having a reversely curved channel and connected to the main chamber by a restricted portion and means for introducing an alkali metal into the main chamber, said alkali metal being maintained out of contact with a substantial portion of said auxiliary chamber by said reversely curved channel and said restricted portion.

6. An envelope for a photo-electric cell comprising a main chamber, an annular auxiliary chamber having a curved channel and connected to the main chamber by a restricted portion and a tube containing an alkali metal connected to the main chamber whereby a deposit of the alkali metal may be formed on the inner wall of the main chamber, by heating the tube, without completely covering the inner wall of the auxiliary chamber.

7. A photo-electric cell comprising an envelope having a main chamber, a film electrode on the inner surface thereof, an auxiliary chamber associated therewith having a reentrant stem portion, a second electrode carried by said stem portion and extending into the main chamber, the outer wall of said auxiliary chamber and said reentrant stem defining a reversely curved annular passage having a plurality of zones free from said film electrode material whereby said electrodes are insulated from each other.

In testimony whereof, I have hereunto

curved annular passage between the outer shell E and the reentrant fold F.

It will be noted, that the electrode M is effectively insulated from the electrode C by a comparatively wide zone extending substantially from the equator of the enlargement K to the restricted portion L of the envelope. It should be further noted that there are two distinct shadow zones or portions protected from the vaporized material emanating from the chamber B, namely that portion of the outer wall of the shell E in the shadow of the restriction L and that portion of the reentrant fold forming the rear side of the enlargement K and in the shadow thereof.

Evidently, if a single bulbous region is insufficient to adequately intercept the volatilized material and prevent it from passing into the tube D, a plurality of such bulbous regions may be used.

Although I have found potassium and sodium to be particularly adapted for use in practicing my invention, rubidium and cæsium may also prove to be suitable light-responsive materials which may be screened in the same manner as potassium. Also, it may be found desirable to limit the deposited area in cells employing light-sensitive materials other than those mentioned. Hence, when I specify a light-sensitive material, I mean to include such materials, other than potassium, as may be found suitable.

What is claimed is:

1. A photo-electric cell comprising an envelope consisting of a main chamber and an auxiliary chamber connected by a restricted neck, said auxiliary chamber having a curved passage forming a plurality of shadow zones, an electrode extending through the wall of the auxiliary chamber and the neck into the main chamber and another electrode extending through the wall of the main chamber, light-sensitive material deposited on the wall of the main chamber, connected with the second electrode and insulated from the first electrode by said shadow zones.

2. A photo-electric cell comprising an envelope consisting of a main chamber and an auxiliary chamber of non-uniform cross section and connected to the main chamber by a restricted neck, an electrode extending through the wall of the auxiliary chamber and the neck into the main chamber, the interior of the wall of the main chamber substantially uniformly coated with a light-sensitive material insulated from the electrode and electrically connected to a leading-in wire extending through the wall of the main chamber.

3. A photo-electric cell comprising an evacuated envelope consisting of a main chamber interiorly coated with alkali metal and an auxiliary annular chamber with a sinuous channel and connected to the main chamber by a restricted portion, an anode extending through the wall of the auxiliary chamber and the restricted portion into the main chamber and a cathode conductor extending through the wall of the main chamber and connected to the deposit of alkali metal on the interior of said wall, but insulated from the leading-in conductor of the anode by said sinuous channel.

4. A photo-electric cell comprising an envelope consisting of a main chamber and an auxiliary annular chamber having a reversely curved channel and connected to the main chamber by a restricted portion, an electrode in the main chamber and connected to a leading-in conductor extending through the restricted portion and the wall of the auxiliary chamber, another electrode extending through the wall of the main chamber and means for introducing alkali metal into the main chamber as a substantially uniform film on the wall thereof, without depositing it on the wall of the auxiliary chamber to a sufficient extent to form a short-circuiting path between the electrodes.

5. An envelope for an electric device comprising a main chamber and an annular auxiliary chamber having a reversely curved channel and connected to the main chamber by a restricted portion and means for introducing an alkali metal into the main chamber, said alkali metal being maintained out of contact with a substantial portion of said auxiliary chamber by said reversely curved channel and said restricted portion.

6. An envelope for a photo-electric cell comprising a main chamber, an annular auxiliary chamber having a curved channel and connected to the main chamber by a restricted portion and a tube containing an alkali metal connected to the main chamber whereby a deposit of the alkali metal may be formed on the inner wall of the main chamber, by heating the tube, without completely covering the inner wall of the auxiliary chamber.

7. A photo-electric cell comprising an envelope having a main chamber, a film electrode on the inner surface thereof, an auxiliary chamber associated therewith having a reentrant stem portion, a second electrode carried by said stem portion and extending into the main chamber, the outer wall of said auxiliary chamber and said reentrant stem defining a reversely curved annular passage having a plurality of zones free from said film electrode material whereby said electrodes are insulated from each other.

In testimony whereof, I have hereunto subscribed my name this 24th day of February, 1921.

ARTHUR H. COMPTON.

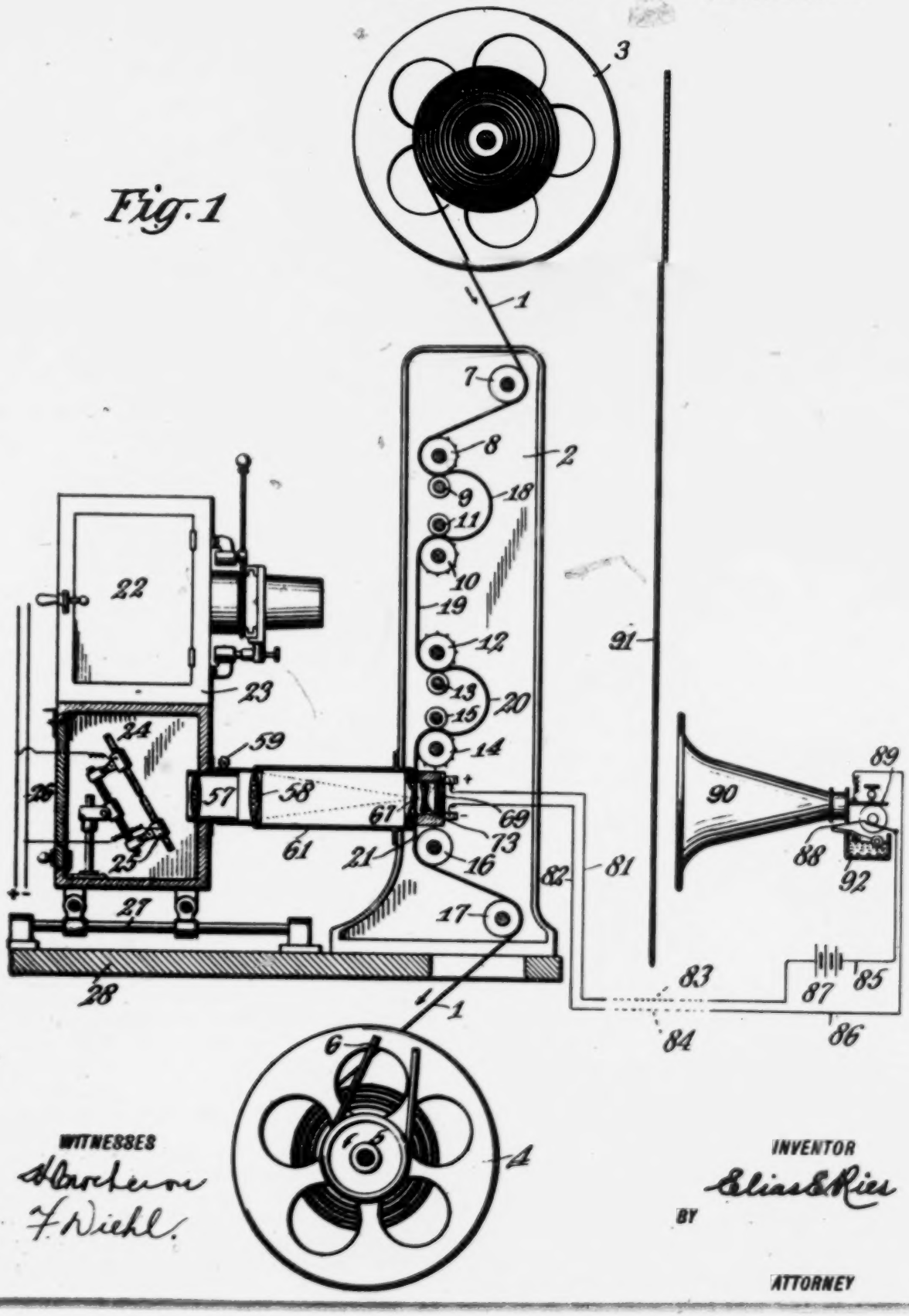
1232 Nov. 16, 1926. 1,607,480

E. E. RIES

METHOD OF REPRODUCING PHOTOGRAPHIC SOUND RECORDS

Filed May 21, 1913 3 Sheets-Sheet 1

Fig. 1



WITNESSES

H. Brochon

F. Diehl.

INVENTOR

Elias E. Ries

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1234 Nov. 16, 1926. 1,607,480

E. E. RIES

METHOD OF REPRODUCING PHOTOGRAPHIC SOUND RECORDS

Filed May 21, 1913 3 Sheets-Sheet 2

Fig. 2.

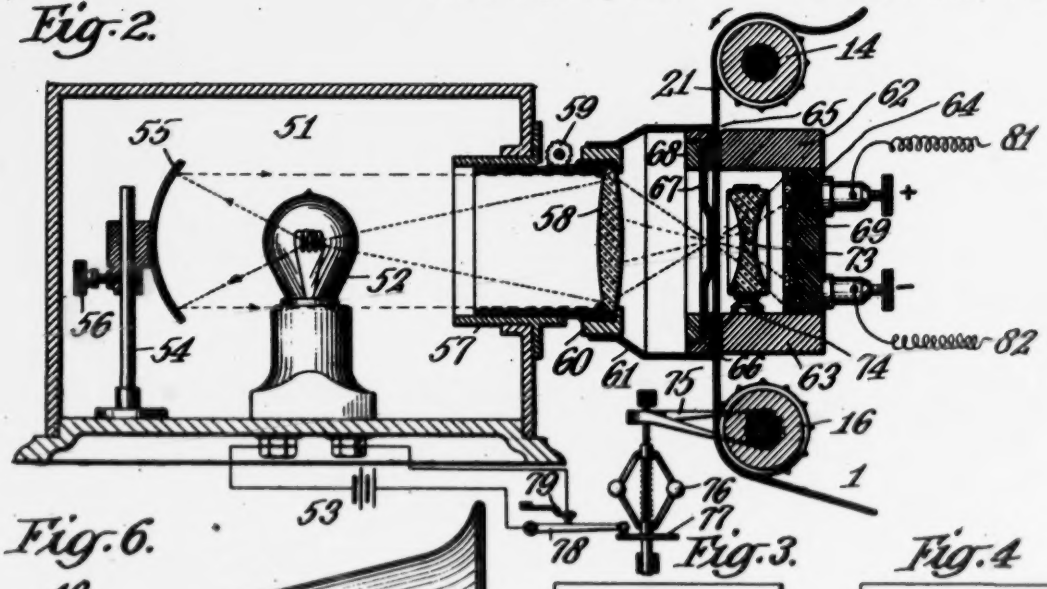


Fig. 6.

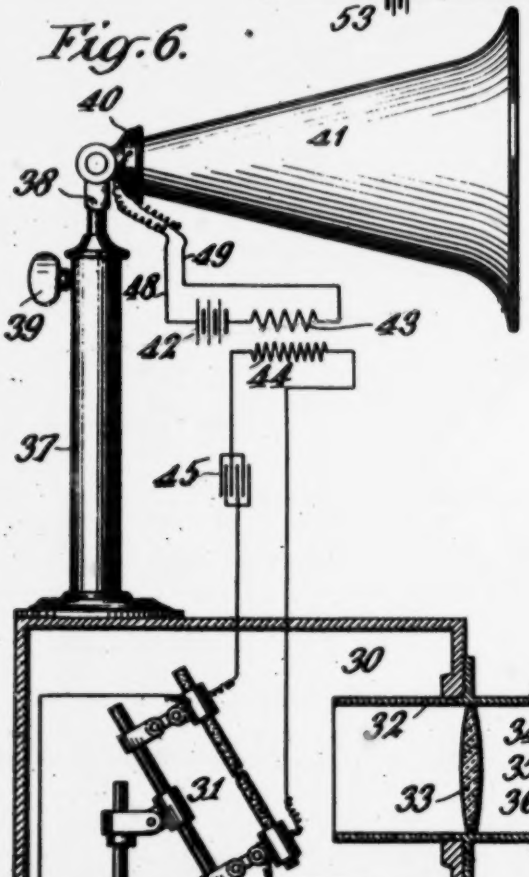


Fig. 3.

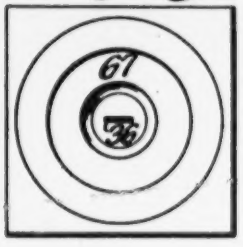


Fig. 4

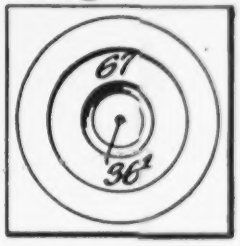
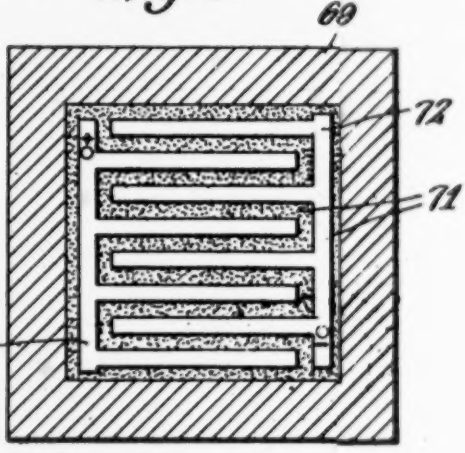


Fig. 5.



WITNESSES

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1236

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METHOD OF REPRODUCING PHOTOGRAPHIC SOUND RECORDS

Filed May 21, 1913 3 Sheets-Sheet 3

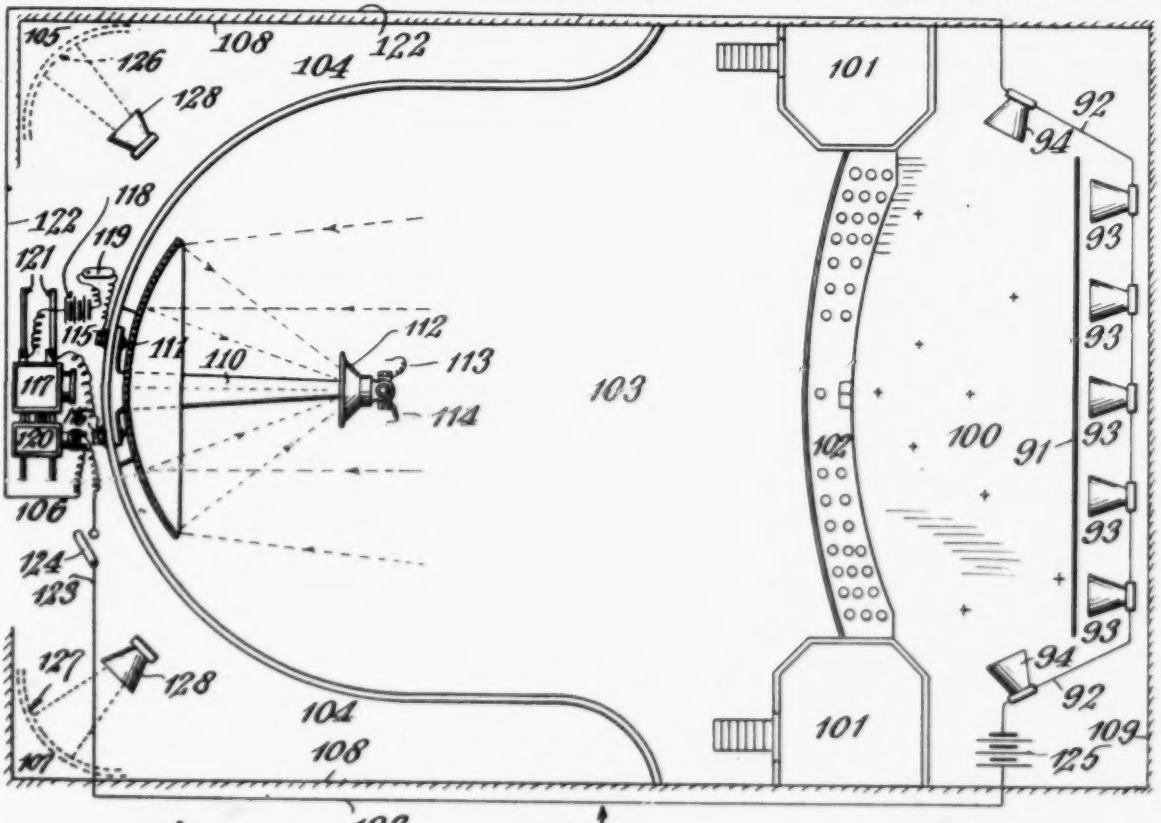
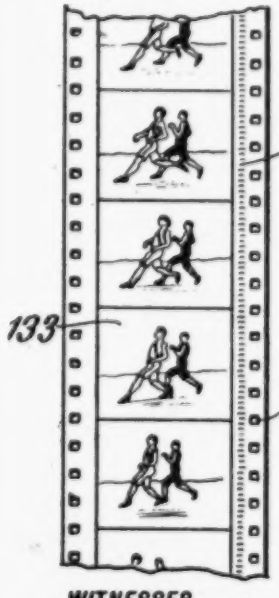


Fig. 8 Fig. 7. Fig. 10

Fig. 9.



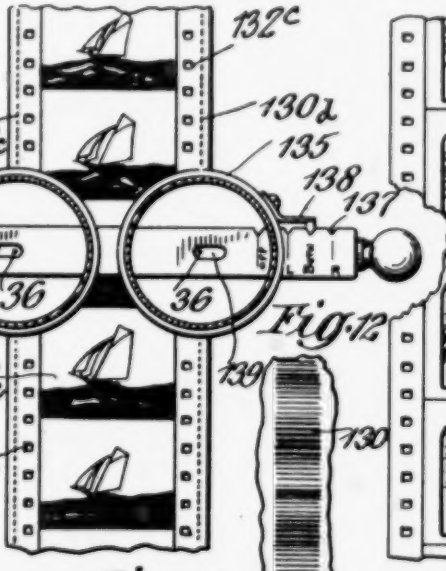


Fig. 12

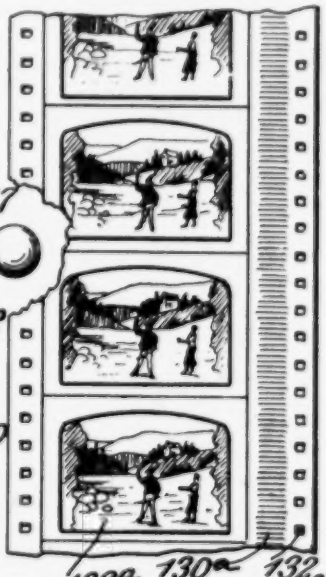
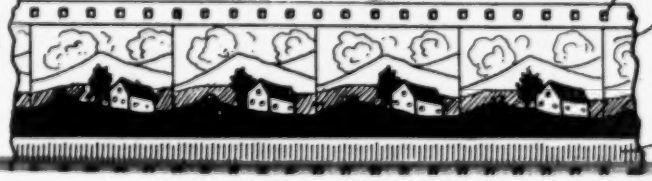


Fig. 11



WITNESSES

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Patented Nov. 16, 1926. 1,607,480

UNITED STATES PATENT OFFICE.

ELIAS E. RIES, OF NEW YORK, N. Y., ASSIGNOR, BY MESNE ASSIGNMENTS, TO DE FOREST PHONOFILM CORPORATION, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE.

METHOD OF REPRODUCING PHOTOGRAPHIC SOUND RECORDS.

Application filed May 21, 1913, Serial No. 769,114. Renewed April 14, 1923.

This invention relates to the method and apparatus for making photographic records of sound by causing the sounds that are to be recorded to produce varying electrical impulses in an electric circuit which in turn cause varying intensities of light for affecting a photographic film. And more particularly it relates to combined motion pictures and sound records photographed on the same film. Also to methods and apparatus for reproducing such sound records or combined motion pictures and sound records.

In carrying my invention into effect I produce a record in the form of a continuous photographic band or stripe of uniform width and of varying degrees of density in the direction of its length corresponding to sound waves impressed upon a diaphragm which cause corresponding varying impulses in an electric circuit. This record is produced by moving the photographic film behind an apertured screen having preferably a very narrow slit aperture with the film in such relation thereto that the area of exposure will be limited to the area of the slit or aperture, and the light rays being so focused upon the screen that the aperture will be flooded with light and affect the sensitive surface of the film uniformly over the exposed area; the purpose of limiting the area of exposure to the area of the slit aperture being to prevent diffusion of light rays beyond the direct image of the aperture. The photographic film at the point where it passes behind the apertured screen moves continuously at a uniform speed, so that when the light remains constant there will result a continuous band of uniform width and density throughout, but as the intensity of the light rays vary in accordance with the varying impulses in the circuit produced by the sound waves impressed on the receiving diaphragm, the density of the band will vary in the direction of movement of the film to a greater or lesser degree than the normal. In other words, when the light remains constant the density of the exposed area will be the mean density, and as the diaphragm vibrates due to sound waves impressed thereon and produces maximum and then decrease to minimum and back to mean density for each complete vibration or cycle. This, owing to the rapidity of the vibrations, results in a record having the appearance of successive lines or stripes extending crosswise of the record band, the lines (in a negative) shading gradually from mean to maximum and then through the mean to minimum and back again to mean density, giving the appearance of waves throughout the length of the record band, and the lines or points of greatest density indicating the crests and the points of least density the hollows of sound waves corresponding to the vibrations of the diaphragm.

To reproduce such a record, I employ a method (which is the subject matter of the present application) in which light rays of constant luminosity are projected through an apertured screen similar to the screen employed in making the record, and the record film is moved constantly at a uniform speed in such relation to the aperture, that only an area equal to the area of the aperture will be exposed to the light rays, and the light rays passing through the record film of varying opacity will be projected upon a light sensitive cell or plate, such as selenium. This cell is connected in an electric circuit connected with a sound reproducing device or telephone, and in accordance with the variations in light rays passing through the record, the light sensitive cell will produce variations in the resistance or cause varying impulses in said circuit to actuate said sound reproducing device or telephone.

In the drawings, Figure 1 is a view partly in section and partly in diagram of the apparatus for reproducing talking motion pictures; Figure 2 is a similar view showing a modified form of the sound reproducing part of the apparatus; Figures 3 and 4 views of two forms of apertured screen for the sound record; Figure 5 a sectional view of the selenium cell; Figure 6 a view partly in section and partly in diagram of one form of that part of the apparatus used for recording the sounds; Figure 7 a plan of a theater showing a stage, orches-

METHOD OF REPRODUCING PHOTOGRAPHIC SOUND RECORDS

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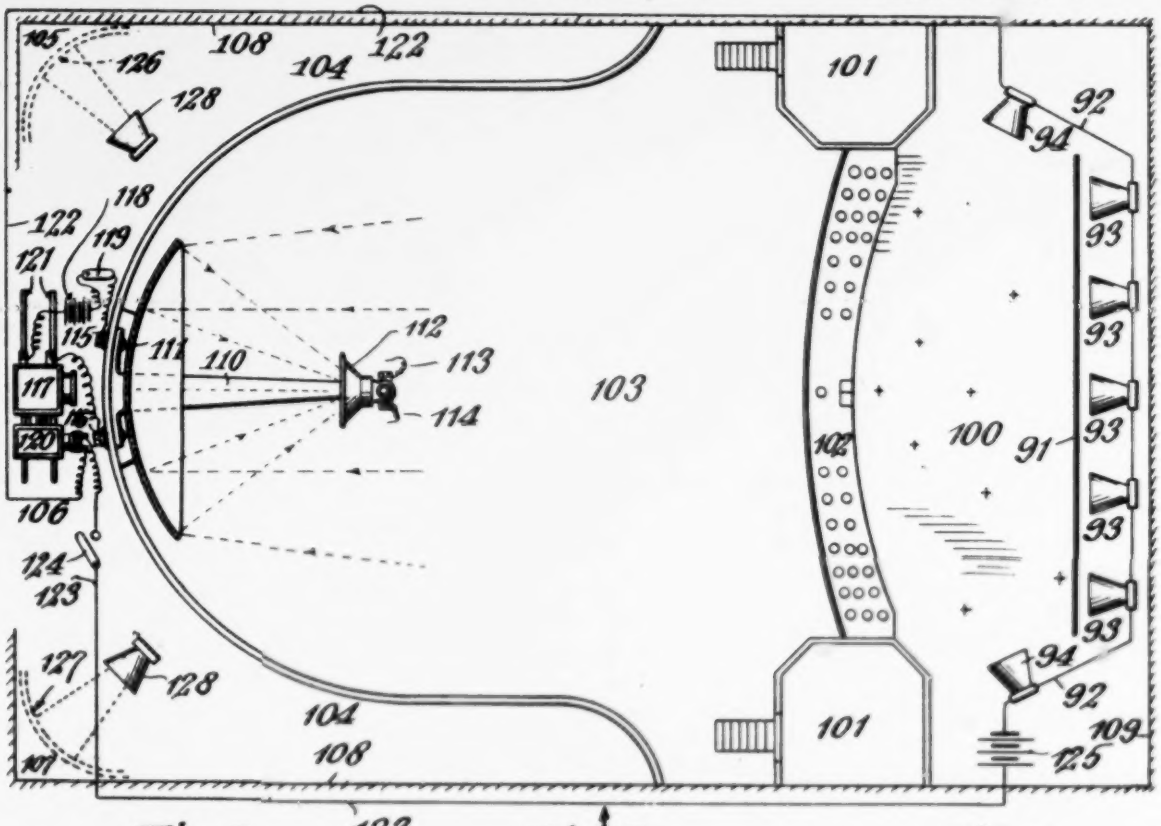

Fig. 8 Fig. 7. Fig. 10

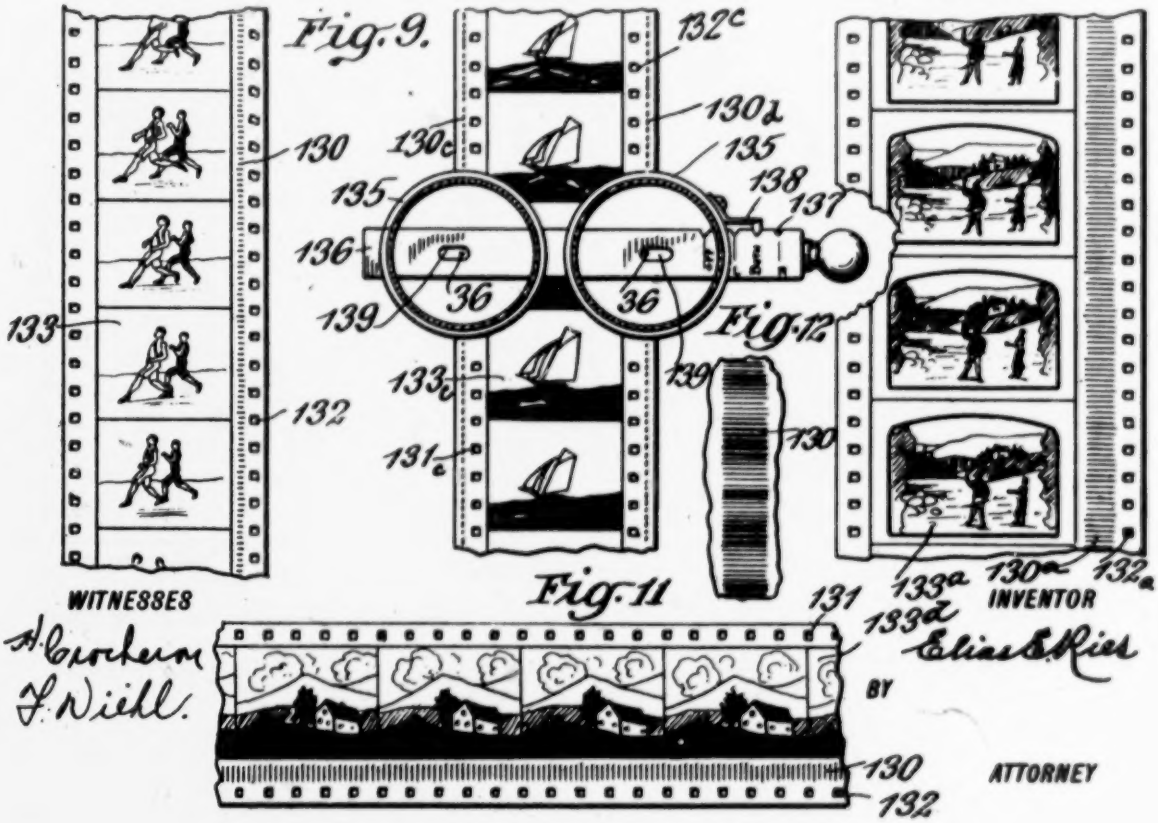

Fig. 9. Fig. 11 Fig. 12

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UNITED STATES PATENT OFFICE.

ELIAS E. RIES, OF NEW YORK, N. Y., ASSIGNOR, BY MESNE ASSIGNMENTS, TO DE FOREST PHONOFILM CORPORATION, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE.

METHOD OF REPRODUCING PHOTOGRAPHIC SOUND RECORDS.

Application filed May 21, 1923, Serial No. 640,114. Renewed April 14, 1923.

This invention relates to the method and apparatus for making photographic records of sound by causing the sounds that are to be recorded to produce varying electrical impulses in an electric circuit which in turn cause varying intensities of light for affecting a photographic film. And more particularly it relates to combined motion pictures and sound records photographed on the same film. Also to methods and apparatus for reproducing such sound records or combined motion pictures and sound records.

In carrying my invention into effect I produce a record in the form of a continuous photographic band or stripe of uniform width and of varying degrees of density in the direction of its length corresponding to sound waves impressed upon a diaphragm which cause corresponding varying impulses in an electric circuit. This record is produced by moving the photographic film behind an apertured screen having preferably a very narrow slit aperture with the film in such relation thereto that the area of exposure will be limited to the area of the slit or aperture, and the light rays being so focused upon the screen that the aperture will be flooded with light and affect the sensitive surface of the film uniformly over the exposed area; the purpose of limiting the area of exposure to the area of the slit aperture being to prevent diffusion of light rays beyond the direct image of the aperture. The photographic film at the point where it passes behind the apertured screen moves continuously at a uniform speed, so that when the light remains constant there will result a continuous band of uniform width and density throughout, but as the intensity of the light rays vary in accordance with the varying impulses in the circuit produced by the sound waves impressed on the receiving diaphragm, the density of the band will vary in the direction of movement of the film to a greater or lesser degree than the normal. In other words, when the light remains constant the density of the exposed area will be the mean density, and as the diaphragm vibrates due to sound waves impressed thereon and producing the varying electrical impulses in the circuit, this density will increase to maximum and then decrease to minimum and back to mean density for each complete vibration or cycle. This, owing to the rapidity of the vibrations, results in a record having the appearance of successive lines or stripes extending crosswise of the record band, the lines (in a negative) shading gradually from mean to maximum and then through the mean to minimum and back again to mean density, giving the appearance of waves throughout the length of the record band, and the lines or points of *greatest density indicating the crests* and the points of least density the hollows of sound waves corresponding to the vibrations of the diaphragm.

To reproduce such a record, I employ a method (which is the subject matter of the present application) in which light rays of constant luminosity are projected through an apertured screen similar to the screen employed in making the record, and the record film is moved constantly at a uniform speed in such relation to the aperture, that only an area equal to the area of the aperture will be exposed to the light rays, and the light rays passing through the record film of varying opacity will be projected upon a light sensitive cell or plate, such as selenium. This cell is connected in an electric circuit connected with a sound reproducing device or telephone, and in accordance with the variations in light rays passing through the record, the light sensitive cell will produce variations in the resistance or cause varying impulses in said circuit to actuate said sound reproducing device or telephone.

In the drawings, Figure 1 is a view partly in section and partly in diagram of the apparatus for reproducing talking motion pictures; Figure 2 is a similar view showing a modified form of the sound reproducing part of the apparatus; Figures 3 and 4 views of two forms of apertured screen for the sound record; Figure 5 a sectional view of the selenium cell; Figure 6 a view partly in section and partly in diagram of one form of that part of the apparatus used for recording the sounds; Figure 7 a plan of a theater showing a stage, orchestra and balcony, with apparatus for taking and reproducing talking motion pictures;

Figure 8 shows an ordinary motion picture film with a single sound record indicated thereon; Figure 9 shows a film with two records thereon, one on each side outside of the sprocket holes; Figure 10 shows a film of extra width affording space for larger picture and sound records; Figure 11 shows a modified form of film in which the picture and sound records are made while moving the film in a horizontal direction instead of vertical; Figure 12 is a view on a large scale of a portion of a sound record, having shading intended to show the gradual changes in translucency representing the sound waves.

In Figure 1 is shown the film 1 as it passes through the picture projecting mechanism of the intermittent feed variety, and then through the sound reproducing apparatus where the film moves constantly. The film may be fed downwardly from the upper reel 3 to the lower reel 4, the latter being provided with the usual "take-up" devices and friction drive pulley 5 with its belt 6, receiving its motion from some uniformly moving portion of the apparatus as usual, or if desired for long productions from some independent motor (not shown). Differential speed control is maintained as usual to insure the proper taking up of the lower portion of the film at a uniform speed irrespective of the varying diameter of the reel.

In taking motion pictures a series of rapid exposures of successive spaces on the film are necessary, usually at the rate of sixteen per second, and with intermittent feed machines this speed cannot be materially increased without damaging the film or losing the light required for successful photography. This period of exposure for each picture space is one-half of this sixteenth of a second, more or less, and the film must remain stationary during exposure. To impress a sound record upon this part of the film while it is subjected to such intermittent action is of course impracticable for obvious reasons. Furthermore during the periods of rest many frequencies of sound waves would be superimposed and blot each other out. Moreover sound recording apparatus applied to the film at its point of exposure for picture taking would interfere with the field of view. Nevertheless synchronism in recording and reproducing the pictures and sounds (with due allowance for the difference in the speed of light and sound waves) is necessary for the best results. This is accomplished both in the recording and reproducing apparatus in the following manner.

12 and its guide roller 13, positively driven sprocket 14 and its guide roller 15, thence under the guide roller 16 and over the roller 17 to the receiving reel 4. This feed mechanism forms the loops 18 and 20, the feed sprockets drawing the film from the upper reel, and the sprockets 10 and 12 feeding it intermittently past the lens system at 19, after which the roller 14 and reel 4 cause the film section 21 to pass through the sound reproducing apparatus (or the recording apparatus) at a uniform constant speed. The loops 18 and 20 may be of a length usually employed in motion picture cameras or projecting machines. The usual shutter and other mechanism commonly employed in cameras or projecting machines will be employed, but for simplicity of illustration such parts are omitted.

There are thus two sections of film, spaced apart a fixed distance, one for intermittent exposure in taking or reproducing motion pictures, and the other for continuous exposure in making or reproducing sound records. The pictures and sounds are recorded or reproduced concurrently, and if film sections 19 and 21 in the reproducing machine are spaced or timed the same as in the recording apparatus the pictures and sounds will be in synchronism when reproduced. Varying the relative positions of film sections 19 and 21, or varying the timing of the two exposures will result in varying the synchronism to compensate for the difference between the speed of light and sound waves, so that they both may be so transmitted over considerable distances as to arrive at the selected point in unison. The first film section 19 is opposite the picture-illuminating section, 22, of the lamp-house 23, and in line with the usual picture-projecting lens and shutter (if one be used) which may be mounted on the frame 2. The lower vertical film section, 21, is opposite the lower section, 24, of the lamp house which, as herein illustrated for convenience of description, is shown as containing an arc lamp, 25, fed from the lighting circuit 26, or any other suitable source. As will be seen, the lamp house 23 is mounted adjustably on guide rails, 27, mounted on the base or stand 28, that carries the entire projecting apparatus.

The lower vertical film section, 21, as well as that portion of the film 1 below the positively-driven sprocket 14, (unlike the upper section 19 and its loops 18 and 20, which are affected by the intermittent-feed mechanism) will travel at a continuous and uniform speed, since the take-up device 5

approximately not more than three picture spaces from section 19, or a total time-interval of about one-fifth (1/5) of a second, (which time interval is susceptible of still further reducation if more than 16 pictures are exhibited per second, that I employ for the reproduction of the sound record that has previously been impressed upon the film along with the pictures. However, I have been able to devise means hereinafter more fully described, whereby even this minute and practically negligible discrepancy in time may be effectively, completely and automatically eliminated.

I prefer for various reasons, in carrying out my invention, to impress such sound waves upon the film in the form of a translucent photographic record. (see Figs. 8 to 12 inclusive,) in which the waves are represented, when developed, by a ribbon or band of varying degrees of translucency represented in the drawings by a series of dots or shaded lines, the parts of the band representing sounds usually merging one into another in continuous succession in the direction of the length of the film. Such a record held to the light, presents a substantially straight band made up of a succession of lights and shadows, in which the alternations of light and shade and the distance between them correspond with and represent the pitch or frequency of the original sound waves, while the depth or intensity of the shading, or the relative degrees of translucency, correspond with and represent their amplitude.

All degrees of light and shade corresponding to the simplest or most complex sound waves may, by properly adjusted and regulated conditions, be accurately recorded.

Fig. 6 shows the sound recording arrangement. In practice it is combined with the camera which may be of any suitable type. The film feeding mechanism may be similar to that shown in Fig. 1 and is not shown in this figure. In the chamber 30 is located any suitable light 31, such for example as an arc light or an incandescent light of any suitable kind capable of having its luminosity varied at the speed of the variations of sound waves. This chamber is provided with a tube, 32, containing a lens, 33, and an adjustable cap-piece, 34, having a raised central portion, 35, pierced with either a narrow slit, 36, as shown in Fig. 3 or a small round or square pin-hole opening 36′ such as shown in Fig. 4, corresponding with light openings of like character that are used in the projecting apparatus illustrated in Figs. 1 and 2.

Mounted at the upper rear portion of the [illegible] such position by wing-nut 39. The upper end of rod 38 has a swivel-joint into which is clamped a telephone-transmitter or microphone 40, which is provided with a large tapering horn or megaphone, 41, designed and adapted to collect the atmospheric sound waves and to direct and focus them upon the diaphragm of the transmitter 40. The minimum height of the horn 41, when the device illustrated in this figure is used in connection with a portable motion-picture camera, is preferably such that the entire camera mechanism, including the chamber 30, containing the photophonic recording appliances, may be mounted as a single, self-contained unit below the line of swing of said horn. The mounting of the horn 41 directly upon the camera apparatus is not essential, as the standard 37, the transmitter 40 and sound receiving horn 41, may be located at convenient points either near the camera or at any desired distance.

The transmitter 40, whether mounted on the apparatus or located at a distance therefrom, is in electrical connection through the circuit or line wires, 48, 49, 42, and primary winding, 43, of an induction-coil whose secondary winding, 44, is in series with a condenser, 45, and with the terminals of the lamp 31, as shown. The terminals of the lamp 31, are likewise independently connected, in the usual manner, by means of the circuit wires shown, with a suitable source of direct current 46, and rheostat 47.

In front of the cap 34, is shown the moving film, 1, traveling downwardly in close proximity to the raised portion 35, so that the portion of its surface intended for the record passes by the light opening 36. This section of the film, indicated by the numeral 21, corresponds with the lower vertical film section 21 in Figs. 1 and 2. It will of course be understood, that the sensitive film 1 in Fig. 6 is completely inclosed and protected from extraneous light by the camera box in which it moves, and that the edge portion or portions of the film on which the photographic record is to be received are shielded from the light and are thus left unexposed during the transit of the film behind the shutter-opening of the picture-taking lens.

The operation of the sound-recording apparatus just described is as follows: Electric energy from the source of direct current 46, passing through rheostat 47 by which its intensity is suitably controlled, travels across the carbons of the lamp 31, forming an arc having the characteristics of a sensitive flame that burns with a steady

Figure 8 shows an ordinary motion picture film with a single sound record indicated thereon; Figure 9 shows a film with two records thereon, one on each side outside of the sprocket holes; Figure 10 shows a film of extra width affording space for larger picture and sound records; Figure 11 shows a modified form of film in which the picture and sound records are made while moving the film in a horizontal direction instead of vertical; Figure 12 is a view on a large scale of a portion of a sound record, having shading intended to show the gradual changes in translucency representing the sound waves.

In Figure 1 is shown the film 1 as it passes through the picture projecting mechanism of the intermittent feed variety, and then through the sound reproducing apparatus where the film moves constantly. The film may be fed downwardly from the upper reel 3 to the lower reel 4, the latter being provided with the usual "take-up" devices and friction drive pulley 5 with its belt 6, receiving its motion from some uniformly moving portion of the apparatus as usual, or if desired for long productions from some independent motor (not shown). Differential speed control is maintained as usual to insure the proper taking up of the lower portion of the film at a uniform speed irrespective of the varying diameter of the reel.

In taking motion pictures a series of rapid exposures of successive spaces on the film are necessary, usually at the rate of sixteen per second, and with intermittent feed machines this speed cannot be materially increased without damaging the film or losing the light required for successful photography. This period of exposure for each picture space is one-half of this sixteenth of a second, more or less, and the film must remain stationary during exposure. To impress a sound record upon this part of the film while it is subjected to such intermittent action is of course impracticable for obvious reasons. Furthermore during the periods of rest many frequencies of sound waves would be superimposed and blot each other out. Moreover sound recording apparatus applied to the film at its point of exposure for picture taking would interfere with the field of view. Nevertheless synchronism in recording and reproducing the pictures and sounds (with due allowance for the difference in the speed of light and sound waves) is necessary for the best results. This is accomplished both in the recording and reproducing apparatus in the following manner.

The film travels in succession over the guide roller 7, positively driven feed sprocket 8, guide roller 9, upper intermittent sprocket 10 and its guide roller 11, down between the lower intermittent feed sprocket 12 and its guide roller 13, positively driven sprocket 14 and its guide roller 15, thence under the guide roller 16 and over the roller 17 to the receiving reel 4. This feed mechanism forms the loops 18 and 20, the feed sprockets drawing the film from the upper reel, and the sprockets 10 and 12 feeding it intermittently past the lens system at 19, after which the roller 14 and reel 4 cause the film section 21 to pass through the sound reproducing apparatus (or the recording apparatus) at a uniform constant speed. The loops 18 and 20 may be of a length usually employed in motion picture cameras or projecting machines. The usual shutter and other mechanism commonly employed in cameras or projecting machines will be employed, but for simplicity of illustration such parts are omitted.

There are thus two sections of film, spaced apart a fixed distance, one for intermittent exposure in taking or reproducing motion pictures, and the other for continuous exposure in making or reproducing sound records. The pictures and sounds are recorded or reproduced concurrently, and if film sections 19 and 21 in the reproducing machine are spaced or timed the same as in the recording apparatus the pictures and sounds will be in synchronism when reproduced. Varying the relative positions of film sections 19 and 21, or varying the timing of the two exposures will result in varying the synchronism to compensate for the difference between the speed of light and sound waves, so that they both may be so transmitted over considerable distances as to arrive at the selected point in unison. The first film section 19 is opposite the picture-illuminating section, 22, of the lamp-house 23, and in line with the usual picture-projecting lens and shutter (if one be used) which may be mounted on the frame 2. The lower vertical film section, 21, is opposite the lower section, 24, of the lamp house which, as herein illustrated for convenience of description, is shown as containing an arc lamp, 25, fed from the lighting circuit 26, or any other suitable source. As will be seen, the lamp house 23 is mounted adjustably on guide rails, 27, mounted on the base or stand 28, that carries the entire projecting apparatus.

The lower vertical film section, 21, as well as that portion of the film 1 below the positively-driven sprocket 14, (unlike the upper section 19 and its loops 18 and 20, which are affected by the intermittent-feed mechanism) will travel at a continuous and uniform speed, since the take-up device 5 causes this portion of the film to be wound up on reel 6 under a slight tension as rapidly as the teeth of the steadily revolving sprocket 14 release it. It is this lower section, 21, therefore, which is removed a distance of

approximately not more than three picture spaces from section 19, or a total time-interval of about one-fifth (⅕) of a second, (which time interval is susceptible of still further reducation if more than 16 pictures are exhibited per second, that I employ for the reproduction of the sound record that has previously been impressed upon the film along with the pictures. However, I have been able to devise means hereinafter more fully described, whereby even this minute and practically negligible discrepancy in time may be effectively, completely and automatically eliminated.

I prefer for various reasons, in carrying out my invention, to impress such sound waves upon the film in the form of a translucent photographic record. (see Figs. 8 to 12 inclusive,) in which the waves are represented, when developed, by a ribbon or band of varying degrees of translucency represented in the drawings by a series of dots or shaded lines, the parts of the band representing sounds usually merging one into another in continuous succession in the direction of the length of the film. Such a record held to the light, presents a substantially straight band made up of a succession of lights and shadows, in which the alternations of light and shade and the distance between them correspond with and represent the pitch or frequency of the original sound waves, while the depth or intensity of the shading, or the relative degrees of translucency, correspond with and represent their amplitude.

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Mounted at the upper rear portion of the apparatus in Fig. 6 is shown a standard 37, containing an adjustable sliding rod 38, that may be extended and turned in any position and if desired may be locked in such position by wing-nut 39. The upper end of rod 38 has a swivel-joint into which is clamped a telephone-transmitter or microphone 40, which is provided with a large tapering horn or megaphone, 41, designed and adapted to collect the atmospheric sound waves and to direct and focus them upon the diaphragm of the transmitter 40. The minimum height of the horn 41, when the device illustrated in this figure is used in connection with a portable motion-picture camera, is preferably such that the entire camera mechanism, including the chamber 30, containing the photophonic recording appliances, may be mounted as a single, self-contained unit below the line of swing of said horn. The mounting of the horn 41 directly upon the camera apparatus is not essential, as the standard 37, the transmitter 40 and sound receiving horn 41, may be located at convenient points either near the camera or at any desired distance.

The transmitter 40, whether mounted on the apparatus or located at a distance therefrom, is in electrical connection through the circuit or line wires, 48, 49, 42, and primary winding, 43, of an induction-coil whose secondary winding, 44, is in series with a condenser, 45, and with the terminals of the lamp 31, as shown. The terminals of the lamp 31, are likewise independently connected, in the usual manner, by means of the circuit wires shown, with a suitable source of direct current 46, and rheostat 47.

In front of the cap 34, is shown the moving film, 1, traveling downwardly in close proximity to the raised portion 35, so that the portion of its surface intended for the record passes by the light opening 36. This section of the film, indicated by the numeral 21, corresponds with the lower vertical film section 21 in Figs. 1 and 2. It will of course be understood, that the sensitive film 1 in Fig. 6 is completely inclosed and protected from extraneous light by the camera box in which it moves, and that the edge portion or portions of the film on which the photographic record is to be received are shielded from the light and are thus left unexposed during the transit of the film behind the shutter-opening of the picture-taking lens.

The operation of the sound-recording apparatus just described is as follows: Electric energy from the source of direct current 46, passing through rheostat 47 by which its intensity is suitably controlled, travels across the carbons of the lamp 31, forming an arc having the characteristics of a sensitive flame that burns with a steady light and at an approximately constant temperature and luminosity. An arc of this character is capable of being converted by a series of slight but rapid variations in the current supply, into what is known as sing-

ing or speaking arc, which is capable of setting up atmospheric vibrations that may be heard directly by the ear at a considerable distance from the arc.

Instead however of employing the arc to set up such audible vibrations, I enclose it within the sound-proof casing 30, and cause variation in the strength of the current corresponding to sound waves to be set up. That is, I produce a series of corresponding variations in the intensity of the light emitted by the lamp, by and in accordance with the speech and other sound waves accompanying the scene or action, and simultaneously impressing the successive variations of intensity of the light upon the moving film in the form of a permanent record.

This result I accomplish in the following manner: The sound waves entering the horn 41 from a distant point are concentrated upon the diaphragm of the microphonic transmitter 40, vibrating the same to vary the resistance of the primary circuit containing the battery 42 and the primary coil 43. The latter induces undulatory or alternating currents of high tension corresponding in form and pitch with the sound waves impinging upon the diaphragm, in the secondary coil 44, which currents pass across the condenser 45 and affect the steady current flowing through the arc, 31, from the dynamo or other source 46. The direct current from this source cannot jump across the condenser 45 nor affect the induction coil 44, so that the net result of the variable current impressed upon the current traversing the lamp 31 is to increase and decrease the intensity of the light in accordance with the original sound waves. The light from the lamp 31, (whether this be an arc or incandescent lamp,) passes into the tube 32 and through the lens 33, which converges the rays over the small slit or opening 36 and at least some of them pass through the slit and strike the moving film 1, thus photographically impressing its sensitive surface with a sound record in the manner already explained. As soon as the film is developed, this record is ready for reproduction.

Instead of employing an arc lamp for recording purposes, as in Fig. 6, I find it equally expedient and more satisfactory to use for this purpose an ordinary tungsten or other metal-filament incandescent lamp, such as I have illustrated in Fig. 2, in which such a lamp is shown as arranged and utilized for reproducing purposes. It is well-known that the efficiency of an incandescent lamp, in terms of candle-power produced for a given consumption of current, is very greatly increased with very small increments wise enhanced. It is these combined qualities that I find particularly useful and which I utilize in my process of converting sound waves into electric waves, electric waves into light waves, and light waves into chemical action upon the film, by the method and appliances already described with reference to Fig. 6. Moreover, in substituting incandescent lamp for the arc, the humming due to the rapid expansion and contraction of a heated gas, such as an arc flame, is substantially eliminated. In addition to this the entire superimposed alternating energy of the talking circuit, impressed upon the normally high candle-power lighting direct current, is effectively employed in alternately raising and lowering the normal candle power of the lamp. This variation, it will be seen, occurs in that part of the spectrum in which the slightest addition or subtraction of electrical energy (such as would be caused by a very small to and fro movement of the transmitter diaphragm,) will produce a considerable fluctuation in candle power and in its resultant actinic or photo-chemical action upon the film. Since the induction coil and condenser used by me cause the setting up of induced currents flowing alternately in opposite directions through the lamp filament, those currents that flow with the normal lamp current serve to reinforce it and augment the candle power, while those that flow against the normal lamp current oppose it and cause a diminution of the normal luminosity.

If this action took place while the filament were burning at a very low candle power, say a bright red, the effect of the superposed telephone current would scarcely be noticeable. But if the filament were burning at a brilliant white, or a bluish white incandescence, such superposition of the telephone current, I have found, will produce a very decided and sharply defined variation in candle power, a variation that is entirely too rapid to be perceptible to the eye, but which is quite strongly marked when produced upon a moving film. However, since by the use of my focusing lens I concentrate a considerable amount of light upon an exceedingly small surface, I find that it is not essential to overstrain the lamp-filament. The strength of the source of light and the photographic materials and speed of photography are adjusted to each other for this purpose in accordance with the well known practice in the photographic art. In fact, a very small tungsten filament lamp using an almost insignificant amount of current will more than suffice to produce a strong, well defined and power-

Coming now to the method and appliances I have devised for reproducing my sound records, reference is made to Fig. 2, which, with certain modifications, shows on a larger scale the sound reproducing apparatus illustrated in Fig. 1, and already partially described.

In Fig. 2, the light chamber, 51, (corresponding with 24 in Fig. 1,) contains a small tungsten or other suitable metal-filament incandescent lamp, 52. This lamp is supplied with direct current from a battery or other source 53. Behind the lamp is mounted a standard, 54, carrying an adjustable reflector 55, which may be secured upon the standard by thumb-screw 56. In front of the lamp, mounted in the wall of the lamp chamber, is a flanged cylinder, 57, which supports an adjustable lens tube provided with a lens, 58, and a rack and pinion, 59, for focussing the lens 58, the latter being shown as secured in its tube by a flanged clamping ring 60. This clamping ring is adapted to enter within a hood, 61, the two forming a light-tight and dust-proof connection between the light-chamber and that part of my sound-reproducing apparatus which co-operates with the film.

This last named apparatus, as shown, consists of a closed, box-like chamber having top and bottom walls 62, 63, two side walls (not shown,) and a rear wall, 64. The top and bottom walls are provided with slots 65, 66, through which the vertical section 21 of the developed film, 1, is free to pass, this section of the film extending between the two lower sprockets 14 and 16, as shown in Fig. 1. The front of the box is closed by the perforated plate 67, (see Figs. 3 and 4,) which may if desired be held in position by a removable clamping frame 68 to facilitate changing the plate to form a wide or a narrow sound record.

Secured to the inner face of the rear wall 64, and preferably covering its entire surface, is a variable, electrical resistance, 69, adapted to be influenced in its conductivity when impinged upon by light. I may employ as such variable resistance a "selenium cell" of any desired or appropriate construction, but I prefer to use a selenium cell or grating, 69, of a special type that I have invented for this purpose, the design and construction of which is illustrated in detail in Fig. 5. This consists of two thin, interlaced sheet-metal stampings, 70 and 72, marked + and — respectively, the space between and around the uniformly spaced, interlaced prongs of which is completely filled with melted selenium, 71. Usually, if desired, a very thin layer of selenium may also be spread over the top surface of the

and —, respectively, secured to the back of the rear wall 64.

Within the chamber, suitably placed between the film section 21 and the variable resistance grating 69, is a small double-concave lens, 73, mounted upon a fixed support, 74, so that its focal axis is opposite the light-opening, 36 or 36′, in the plate 67. Upon the shaft of the lower guide roll 16, which if desired may be in the form of a sprocket wheel, I place a small belt 75, arranged to drive a centrifugal governor 76, whose disc, 77, is adapted to raise and lower a lever 78, so as to make or break the circuit of battery 53.

The purpose and function of this governor, 76, and its associated parts, as will be apparent, is automatically to open the circuit of battery, 53, and thus to extinguish the lamp 52, if for any reason the speed of the film 1 is unduly reduced, or when the projecting machine comes to a stop, or again during the starting up of the same from a position of rest until it has gained its minimum or normal operative speed. In this manner, I eliminate all possibility of accidently overheating or burning the film by reason of any prolonged focusing of the light from the lamp 52, upon any given spot on the same. I will say, in passing, that I may also use the same governor to extinguish the picture-projecting lamp, particularly if this be of the high candle-power incandescent type which under certain operating conditions I find it feasible to substitute for the arc, and thereby dispense with the usual fire-shutters now generally employed. The use of this automatic lamp extinguishing safety device will serve, incidentally, to insure a more correct and uniform operation of the projecting apparatus on the part of the attendant.

The operation of the remaining devices described with reference to Fig. 2 are as follows. The rearwardly extending light-rays from the incandescent lamp 52, impinge upon the reflector 55, which in some cases I may make in the form of a parabolic reflector having the lamp, 52, in the focus thereof. From this reflector they are projected against the lens 59, as indicated by the arrows. The forwardly extending rays from the lamp filament are in like manner directly projected upon the same lens, being added to those coming from the reflector 55. The lens 59 concentrates and brings the combined rays thus falling upon it to a focus directly upon that given spot of my sound record, usually located near one edge of the translucent film-section 21, (as indicated more clearly in Figs. 8, 9 and 10,) which at the

ing or speaking arc, which is capable of setting up atmospheric vibrations that may be heard directly by the ear at a considerable distance from the arc.

Instead however of employing the arc to set up such audible vibrations, I enclose it within the sound-proof casing 30, and cause variation in the strength of the current corresponding to sound waves to be set up. That is, I produce a series of corresponding variations in the intensity of the light emitted by the lamp, by and in accordance with the speech and other sound waves accompanying the scene or action, and simultaneously impressing the successive variations of intensity of the light upon the moving film in the form of a permanent record.

This result I accomplish in the following manner: The sound waves entering the horn 41 from a distant point are concentrated upon the diaphragm of the microphonic transmitter 40, vibrating the same to vary the resistance of the primary circuit containing the battery 42 and the primary coil 43. The latter induces undulatory or alternating currents of high tension corresponding in form and pitch with the sound waves impinging upon the diaphragm, in the secondary coil 44, which currents pass across the condenser 45 and affect the steady current flowing through the arc, 31, from the dynamo or other source 46. The direct current from this source cannot jump across the condenser 45 nor affect the induction coil 44, so that the net result of the variable current impressed upon the current traversing the lamp 31 is to increase and decrease the intensity of the light in accordance with the original sound waves. The light from the lamp 31, (whether this be an arc or incandescent lamp,) passes into the tube 32 and through the lens 33, which converges the rays over the small slit or opening 36 and at least some of them pass through the slit and strike the moving film 1, thus photographically impressing its sensitive surface with a sound record in the manner already explained. As soon as the film is developed, this record is ready for reproduction.

Instead of employing an arc lamp for recording purposes, as in Fig. 6, I find it equally expedient and more satisfactory to use for this purpose an ordinary tungsten or other metal-filament incandescent lamp, such as I have illustrated in Fig. 2, in which such a lamp is shown as arranged and utilized for reproducing purposes. It is well-known that the efficiency of an incandescent lamp, in terms of candle-power produced for a given consumption of current, is very greatly increased with very small increments of current after the lamp has already been raised to and is normally burning at, a relatively high intensity. Furthermore, its actinic power under these conditions is likewise enhanced. It is these combined qualities that I find particularly useful and which I utilize in my process of converting sound waves into electric waves, electric waves into light waves, and light waves into chemical action upon the film, by the method and appliances already described with reference to Fig. 6. Moreover, in substituting incandescent lamp for the arc, the humming due to the rapid expansion and contraction of a heated gas, such as an arc flame, is substantially eliminated. In addition to this the entire superimposed alternating energy of the talking circuit, impressed upon the normally high candle-power lighting direct current, is effectively employed in alternately raising and lowering the normal candle power of the lamp. This variation, it will be seen, occurs in that part of the spectrum in which the slightest addition or subtraction of electrical energy (such as would be caused by a very small to and fro movement of the transmitter diaphragm,) will produce a considerable fluctuation in candle power and in its resultant actinic or photo-chemical action upon the film. Since the induction coil and condenser used by me cause the setting up of induced currents flowing alternately in opposite directions through the lamp filament, those currents that flow with the normal lamp current serve to reinforce it and augment the candle power, while those that flow against the normal lamp current oppose it and cause a diminution of the normal luminosity.

If this action took place while the filament were burning at a very low candle power, say a bright red, the effect of the superposed telephone current would scarcely be noticeable. But if the filament were burning at a brilliant white, or a bluish white incandescence, such superposition of the telephone current, I have found, will produce a very decided and sharply defined variation in candle power, a variation that is entirely too rapid to be perceptible to the eye, but which is quite strongly marked when produced upon a moving film. However, since by the use of my focusing lens I concentrate a considerable amount of light upon an exceedingly small surface, I find that it is not essential to overstrain the lamp-filament. The strength of the source of light and the photographic materials and speed of photography are adjusted to each other for this purpose in accordance with the well known practice in the photographic art. In fact, a very small tungsten filament lamp using an almost insignificant amount of current will more than suffice to produce a strong, well defined and powerful record, a record that is practically free from all scratching and other extraneous mechanical sounds inseparable from the use of ordinary phonographic records.

Coming now to the method and appliances I have devised for reproducing my sound records, reference is made to Fig. 2, which, with certain modifications, shows on a larger scale the sound reproducing apparatus illustrated in Fig. 1, and already partially described.

In Fig. 2, the light chamber, 51, (corresponding with 24 in Fig. 1,) contains a small tungsten or other suitable metal-filament incandescent lamp, 52. This lamp is supplied with direct current from a battery or other source 53. Behind the lamp is mounted a standard, 54, carrying an adjustable reflector 55, which may be secured upon the standard by thumb-screw 56. In front of the lamp, mounted in the wall of the lamp chamber, is a flanged cylinder, 57, which supports an adjustable lens tube provided with a lens, 58, and a rack and pinion, 59, for focussing the lens 58, the latter being shown as secured in its tube by a flanged clamping ring 60. This clamping ring is adapted to enter within a hood, 61, the two forming a light-tight and dust-proof connection between the light-chamber and that part of my sound-reproducing apparatus which co-operates with the film.

This last named apparatus, as shown, consists of a closed, box-like chamber having top and bottom walls 62, 63, two side walls (not shown,) and a rear wall, 64. The top and bottom walls are provided with slots 65, 66, through which the vertical section 21 of the developed film, 1, is free to pass, this section of the film extending between the two lower sprockets 14 and 16, as shown in Fig. 1. The front of the box is closed by the perforated plate 67, (see Figs. 3 and 4,) which may if desired be held in position by a removable clamping frame 68 to facilitate changing the plate to form a wide or a narrow sound record.

Secured to the inner face of the rear wall 64, and preferably covering its entire surface, is a variable, electrical resistance, 69, adapted to be influenced in its conductivity when impinged upon by light. I may employ as such variable resistance a "selenium cell" of any desired or appropriate construction, but I prefer to use a selenium cell or grating, 69, of a special type that I have invented for this purpose, the design and construction of which is illustrated in detail in Fig. 5. This consists of two thin, interlaced sheet-metal stampings, 70 and 72, marked + and — respectively, the space between and around the uniformly spaced, interlaced prongs of which is completely filled with melted selenium, 71. Usually, if desired, a very thin layer of selenium may also be spread over the top surface of the grating 69, that is formed by the two conducting grids 70 and 72. These grids terminate in a pair of binding posts, marked + and —, respectively, secured to the back of the rear wall 64.

Within the chamber, suitably placed between the film section 21 and the variable resistance grating 69, is a small double-concave lens, 73, mounted upon a fixed support, 74, so that its focal axis is opposite the light-opening, 36 or 36′, in the plate 67. Upon the shaft of the lower guide roll 16, which if desired may be in the form of a sprocket wheel, I place a small belt 75, arranged to drive a centrifugal governor 76, whose disc, 77, is adapted to raise and lower a lever 78, so as to make or break the circuit of battery 53.

The purpose and function of this governor, 76, and its associated parts, as will be apparent, is automatically to open the circuit of battery, 53, and thus to extinguish the lamp 52, if for any reason the speed of the film 1 is unduly reduced, or when the projecting machine comes to a stop, or again during the starting up of the same from a position of rest until it has gained its minimum or normal operative speed. In this manner, I eliminate all possibility of accidently overheating or burning the film by reason of any prolonged focusing of the light from the lamp 52, upon any given spot on the same. I will say, in passing, that I may also use the same governor to extinguish the picture-projecting lamp, particularly if this be of the high candle-power incandescent type which under certain operating conditions I find it feasible to substitute for the arc, and thereby dispense with the usual fire-shutters now generally employed. The use of this automatic lamp extinguishing safety device will serve, incidentally, to insure a more correct and uniform operation of the projecting apparatus on the part of the attendant.

The operation of the remaining devices described with reference to Fig. 2 are as follows. The rearwardly extending light-rays from the incandescent lamp 52, impinge upon the reflector 55, which in some cases I may make in the form of a parabolic reflector having the lamp, 52, in the focus thereof. From this reflector they are projected against the lens 59, as indicated by the arrows. The forwardly extending rays from the lamp filament are in like manner directly projected upon the same lens, being added to those coming from the reflector 55. The lens 59 concentrates and brings the combined rays thus falling upon it to a focus directly upon that given spot of my sound record, usually located near one edge of the translucent film-section 21, (as indicated more clearly in Figs. 8, 9 and 10,) which at the moment is passing behind the narrow slit or light-opening 36. It will thus be evident that this spot, which may represent, say a portion of a single sound wave, is very

highly illuminated, and that the amount of light transmitted through the film at this spot will depend directly upon its relative degree of translucency, which changes rapidly from moment to moment with each succeeding wave that passes the slit. The light rays pass, preferably through a small double-concave lens 73, which is placed close to the film causing them to diverge and to spread preferably over the whole of the large area of my selenium grating 69, as shown by the dotted lines. By this novel means I produce a wide and uniformly distributed variation in the electrical resistance of the selenium between the + and — grids, 70 and 71, which variation will be in substantially direct proportion to the varying intensity of the distributed light.

It may be mentioned here that in reproducing my photophonic sound records, it is not essential to have the emulsion side of the translucent film face the light rays coming from the lamp 52. It suffices merely to transmit the convergent rays at the desired focal intensity through the film so that the plane of the photographically developed sound-record surface will intersect and pass through the concentrated light rays. I prefer to place my sound-reproducing lamp 52, together with its light concentrating and projecting system, on the opposite side of the film from that shown in the drawings, thus reversing the position, with reference to the film 1 at the point 21, of the lamp 52 and the selenium grating 69. Moreover, in the reproduction of my photographic sound records, unlike the reproduction of an ordinary photograph, the sound is the same whether it is reproduced from a negative or a positive print.

On referring to Fig. 1, the manner in which the variation in the electrical resistance of the grating 69 is utilized in the present application of my invention, will now be made clear. To the + and — binding posts of the selenium grating 69, are attached the conducting wires 81 and 82. These wires extend, let us assume, from a picture-projecting booth located on or above the balcony of a theater,—in which booth the entire projection apparatus shown at the left hand portion of Fig. 1 is placed,—to the stage of the same theater. The location of this stage is represented at the right-hand portion of Fig. 1 by the talking-picture screen, 91, and the sound-reproducing horn 90, of my photophonoscope.

The dotted lines 83, 84, represent a continuation of the conducting wires 81, 82, and are run from the aforesaid balcony and joined to the remaining circuit wires, 85, with one or more telephone receivers placed on the stage, generally behind the screen 91, and in this case the battery 87 is alone sufficient, without any additional appliances, to cause an absolutely pure reproduction of the photographed voice-record, by virtue of the changing resistance of the selenium grating 69, and the automatic corresponding increase and decrease of the current which the battery 87 sends through the telephone or telephones.

However, in order to increase the volume of the reproduced sound, especially when my apparatus is used in large auditoriums, I preferably introduce in this circuit any suitable amplifying device or devices, by which speech may be intensified to fill the entire auditorium. I have illustrated as one type of such amplifying device that I find useful for this purpose, a loud-speaking electro-chemical telephone receiver of a well-known type, to the terminals of which the wires 85 and 86 are connected. This apparatus consists essentially of a diaphragm of relatively large diameter, which I place within the base of the megaphone 90, said diaphragm having a flexible, spring-pressed metallic arm, preferably of palladium, 89, extending from the center thereof and bearing upon the surface of a uniformly driven rotating cylinder, 88, preferably of compressed chalk, that is kept in a moistened condition by any suitable means, as by an occasional wetting of its surface about once or twice a week, from the liquid-containing receptacle 92. With the shaft of cylinder 88, one of the wires leading from the battery, 87, is in electrical contact, the other wire being connected with the arm 89. In some cases I may also introduce an induction coil in this circuit to augment the effect. The passage of a variable current between the moistened cylinder and the arm, by its electrolytic action, effects a corresponding and very pronounced variation in the mechanical friction between the two surfaces. In this manner, oscillations of large amplitude are produced in the diaphragm, in exact accordance with the density of the photographic sound record on the film, 1. The effect of these oscillations upon the column of air contained within the megaphone 90 is such as to still further augment the volume of sound emitted, so that it becomes possible with this arrangement of the various parts of my apparatus, audibly to reproduce and amplify the sound record on the film to such an extent, if necessary, that the reproduced speech, vocal, instrumental and other sounds will be louder and carry farther than the original sound vibrations themselves.

employ any other form of telephonic relay or other sound amplifying devices.

It will now be clear how the original atmospheric sound waves incidental to a given act or scene are automatically converted into light waves, the light waves into a chemical sound record upon the film, and which, together with a similar record of the series of pictures of the scene taken therewith upon the same film, are developed to form a photographic negative, and how this combined picture and sound record may subsequently be transferred, by photoprinting in the usual manner, upon any desired number of positive films. It will further be clear how the voice or other sound record, by merely passing either the negative or a positive film through the reproducing machine in the usual manner, is again automatically and instantaneously converted into light waves, the light waves into electric current waves and the electrical waves either into electro-magnetic waves that operate the diaphragms of one or more telephone receivers by which they are directly again converted into sound waves, or into electro-chemical or other equivalent waves or impulses by which they are amplified, and the amplified waves finally converted into reinforced sound waves that are a reproduction of the original sound waves, free from all superimposed or extraneous disturbing influences.

Notwithstanding the slight difference in displacement between the picture-section 19, and the sound-record section 21, of the film 1, it is possible to project both the picture and the sound corresponding therewith so that they will reach the observer simultaneously and in synchronism. I will now describe one or two methods by which I accomplish this in operating my picture taking and projecting apparatus.

Let us assume that the distance between the screen and the average center of the total number of auditors, as generally distributed throughout the floor and galleries of a large play-house, to be say, 115 feet. The light from the picture reaches the eyes of the auditor at that distance instantaneously, while owing to its lesser speed, the sound would lag behind approximately one-tenth of a second. Of course, it will be realized that this has always been the case in auditoriums, in which the voice of a speaker or singer lags more or less as heard by the auditor, (according to the latter's distance from the stage,) behind the lip motion accompanying the utterance. Consequently, if this can be rectified by talking pictures a decided gain will have been accomplished over the actual performance.

respectively, at some distance on the film below that of the corresponding picture, this overlapping of the two records amounting as was stated, to a time interval, if measured along the length of the film, of approximately one-fifth of a second. But inasmuch as the picture and voice sections, 19 and 21, of the film, are simultaneously exposed at their respective optical centers, both in taking and reproducing the combined record, this apparent displacement is automatically neutralized, and the voice and its picture are normally in as perfect synchronism as if they were both impressed alongside of each other on the film section 19. It still remains, however, to compensate for the slight difference between the speed of the light and sound waves.

It will now become apparent that, in the taking of my picture, it is not essential that the receiving horn, 41, (Fig. 6) be removed to the distance of the average auditor, but it may be placed much nearer the stage than the camera and the voice transmitted to the latter electrically at the same speed as light. The photographic record of this voice will thus be impressed upon the traveling film so as to overtake the photographic record of its corresponding motion-picture, especially since the former is susceptible of being impressed on the negative film at a point several pictures in advance of the latter, as will presently appear. In reproducing from the positive film, the voice record is likewise electrically transmitted from the projecting machine to the stage (as well as to any other desired points in the auditorium), at which it is telephonically reconverted into sound, in advance of the projection of its picture. By thus transmitting sound waves electrically in both directions, at the speed of light, in the manner described, both the sound and the picture may reach the middle of audience simultaneously.

Any desired amount of such phase-displacement along the film, or inter-compensation between the light and sound record, may be given to suit different conditions that may arise, and the same film record may be adjusted to suit such different conditions so as to produce synchronism whether the sound waves are transmitted electrically or by the intervening atmosphere. For example, in taking talking-pictures I may and preferably do normally lengthen the lower loop, 20, to the extent of two, three, or more additional pictures, in which case the sound record can be made to overtake the corresponding scene record to a still greater extent. In exhibiting reproductions of this film in auditoriums of dif-

highly illuminated, and that the amount of light transmitted through the film at this spot will depend directly upon its relative degree of translucency, which changes rapidly from moment to moment with each succeeding wave that passes the slit. The light rays pass, preferably through a small double-concave lens 73, which is placed close to the film causing them to diverge and to spread preferably over the whole of the large area of my selenium grating 69, as shown by the dotted lines. By this novel means I produce a wide and uniformly distributed variation in the electrical resistance of the selenium between the + and — grids, 70 and 71, which variation will be in substantially direct proportion to the varying intensity of the distributed light.

It may be mentioned here that in reproducing my photophonic sound records, it is not essential to have the emulsion side of the translucent film face the light rays coming from the lamp 52. It suffices merely to transmit the convergent rays at the desired focal intensity through the film so that the plane of the photographically developed sound-record surface will intersect and pass through the concentrated light rays. I prefer to place my sound-reproducing lamp 52, together with its light concentrating and projecting system, on the opposite side of the film from that shown in the drawings, thus reversing the position, with reference to the film 1 at the point 21, of the lamp 52 and the selenium grating 69. Moreover, in the reproduction of my photographic sound records, unlike the reproduction of an ordinary photograph, the sound is the same whether it is reproduced from a negative or a positive print.

On referring to Fig. 1, the manner in which the variation in the electrical resistance of the grating 69 is utilized in the present application of my invention, will now be made clear. To the + and — binding posts of the selenium grating 69, are attached the conducting wires 81 and 82. These wires extend, let us assume, from a picture-projecting booth located on or above the balcony of a theater,—in which booth the entire projection apparatus shown at the left hand portion of Fig. 1 is placed,—to the stage of the same theater. The location of this stage is represented at the right-hand portion of Fig. 1 by the talking-picture screen, 91, and the sound-reproducing horn 90. of my photophonoscope.

The dotted lines 83, 84, represent a continuation of the conducting wires 81, 82, and are run from the aforesaid balcony and joined to the remaining circuit wires, 85, 86, located on the stage, a primary battery, 87, being included at any convenient point in the sound reproducing circuit. Ordinarily, I may connect the wires 85 and 86 directly with one or more telephone receivers placed on the stage, generally behind the screen 91, and in this case the battery 87 is alone sufficient, without any additional appliances, to cause an absolutely pure reproduction of the photographed voice-record, by virtue of the changing resistance of the selenium grating 69, and the automatic corresponding increase and decrease of the current which the battery 87 sends through the telephone or telephones.

However, in order to increase the volume of the reproduced sound, especially when my apparatus is used in large auditoriums, I preferably introduce in this circuit any suitable amplifying device or devices, by which speech may be intensified to fill the entire auditorium. I have illustrated as one type of such amplifying device that I find useful for this purpose, a loud-speaking electro-chemical telephone receiver of a well-known type, to the terminals of which the wires 85 and 86 are connected. This apparatus consists essentially of a diaphragm of relatively large diameter, which I place within the base of the megaphone 90, said diaphragm having a flexible, spring-pressed metallic arm, preferably of palladium, 89, extending from the center thereof and bearing upon the surface of a uniformly driven rotating cylinder, 88, preferably of compressed chalk, that is kept in a moistened condition by any suitable means, as by an occasional wetting of its surface about once or twice a week, from the liquid-containing receptacle 92. With the shaft of cylinder 88, one of the wires leading from the battery, 87, is in electrical contact, the other wire being connected with the arm 89. In some cases I may also introduce an induction coil in this circuit to augment the effect. The passage of a variable current between the moistened cylinder and the arm, by its electrolytic action, effects a corresponding and very pronounced variation in the mechanical friction between the two surfaces. In this manner, oscillations of large amplitude are produced in the diaphragm, in exact accordance with the density of the photographic sound record on the film, 1. The effect of these oscillations upon the column of air contained within the megaphone 90 is such as to still further augment the volume of sound emitted, so that it becomes possible with this arrangement of the various parts of my apparatus, audibly to reproduce and amplify the sound record on the film to such an extent, if necessary, that the reproduced speech, vocal, instrumental and other sounds will be louder and carry farther than the original sound vibrations themselves.

Although I have herein shown and described one specific type of sound-amplifying apparatus, I desire it understood that I do not limit myself to this type, as I may

employ any other form of telephonic relay or other sound amplifying devices.

It will now be clear how the original atmospheric sound waves incidental to a given act or scene are automatically converted into light waves, the light waves into a chemical sound record upon the film, and which, together with a similar record of the series of pictures of the scene taken therewith upon the same film, are developed to form a photographic negative, and how this combined picture and sound record may subsequently be transferred, by photo-printing in the usual manner, upon any desired number of positive films. It will further be clear how the voice or other sound record, by merely passing either the negative or a positive film through the reproducing machine in the usual manner, is again automatically and instantaneously converted into light waves, the light waves into electric current waves and the electrical waves either into electro-magnetic waves that operate the diaphragms of one or more telephone receivers by which they are directly again converted into sound waves, or into electro-chemical or other equivalent waves or impulses by which they are amplified, and the amplified waves finally converted into reinforced sound waves that are a reproduction of the original sound waves, free from all superimposed or extraneous disturbing influences.

Notwithstanding the slight difference in displacement between the picture-section 19, and the sound-record section 21, of the film 1, it is possible to project both the picture and the sound corresponding therewith so that they will reach the observer simultaneously and in synchronism. I will now describe one or two methods by which I accomplish this in operating my picture taking and projecting apparatus.

Let us assume that the distance between the screen and the average center of the total number of auditors, as generally distributed throughout the floor and galleries of a large play-house, to be say, 115 feet. The light from the picture reaches the eyes of the auditor at that distance instantaneously, while owing to its lesser speed, the sound would lag behind approximately one-tenth of a second. Of course, it will be realized that this has always been the case in auditoriums, in which the voice of a speaker or singer lags more or less as heard by the auditor, (according to the latter's distance from the stage,) behind the lip motion accompanying the utterance. Consequently, if this can be rectified by talking pictures a decided gain will have been accomplished over the actual performance.

Now, it has been mentioned that, both in my camera and in my reproducing machine, speech is impressed and reproduced, respectively, at some distance on the film below that of the corresponding picture, this overlapping of the two records amounting as was stated, to a time interval, if measured along the length of the film, of approximately one-fifth of a second. But inasmuch as the picture and voice sections, 19 and 21, of the film, are simultaneously exposed at their respective optical centers, both in taking and reproducing the combined record, this apparent displacement is automatically neutralized, and the voice and its picture are normally in as perfect synchronism as if they were both impressed alongside of each other on the film section 19. It still remains, however, to compensate for the slight difference between the speed of the light and sound waves.

It will now become apparent that, in the taking of my picture, it is not essential that the receiving horn, 41, (Fig. 6) be removed to the distance of the average auditor, but it may be placed much nearer the stage than the camera and the voice transmitted to the latter electrically at the same speed as light. The photographic record of this voice will thus be impressed upon the traveling film so as to overtake the photographic record of its corresponding motion-picture, especially since the former is susceptible of being impressed on the negative film at a point several pictures in advance of the latter, as will presently appear. In reproducing from the positive film, the voice record is likewise electrically transmitted from the projecting machine to the stage (as well as to any other desired points in the auditorium), at which it is telephonically reconverted into sound, in advance of the projection of its picture. By thus transmitting sound waves electrically in both directions, at the speed of light, in the manner described, both the sound and the picture may reach the middle of audience simultaneously.

Any desired amount of such phase-displacement along the film, or inter-compensation between the light and sound record, may be given to suit different conditions that may arise, and the same film record may be adjusted to suit such different conditions so as to produce synchronism whether the sound waves are transmitted electrically or by the intervening atmosphere. For example, in taking talking-pictures I may and preferably do normally lengthen the lower loop, 20, to the extent of two, three, or more additional pictures, in which case the sound record can be made to overtake the corresponding scene record to a still greater extent. In exhibiting reproductions of this film in auditoriums of different sizes, all the operator need then do is, in threading up his projecting machine, to adjust the length of this loop to the

size of the exhibition hall, or to the average distance that the reproduced sound will have to travel, in order to secure registration between the picture and its sound in the auditorium. By the use of this simple and effective expedient, it becomes immaterial whether the voice record is taken at a point closer to the scene than the picture record, or at the same distance. It will thus be seen that my system is sufficiently flexible to lend itself to the proper taking and reproduction of every conceivable kind of subjects and under the most diverse conditions, with the assurance that either natural or absolute registration between the sound and its picture, whichever may be preferred, be secured and maintained.

Referring now to Fig. 7, this represents a plan view of part of a theater or opera-house, in which performances for my talking-pictures may be staged and in which such pictures may likewise be reproduced. In this figure, 100 represents the stage: 101, the proscenium boxes in front of the wings; 102, the space reserved for the orchestra; 103, the space occupied, below the stage level, by the orchestra seats; 104, the first or second balcony circle; 106, the space behind or over the balcony circle for the picture taking and projecting apparatus; 105 and 107, reserved spaces in the respective corners of the balcony; 108, the side walls of the auditorium; and 109, the rear or stage wall of the same.

Fixed to the front wall of the balcony, at the center thereof and in a position where it will not interfere with the view of the stage, I provide a concave sound-collecting board, 111, secured to said wall by a bracket arm 110, which extends forward and supports near its outer extremity and in such a position as to be directly in the focus of said sound collecting board, a wide-mouthed microphone-transmitter, 112. Wires 113 and 114 run from the transmitter terminals, back along the arm 110 to insulated binding posts 115 and 116, which connect by means of the transmitter circuit wires shown, with the sound-recording appliances of the picture-taking camera, 117. Included in this circuit is shown the transmitter battery 118, and a switch, 119, for opening the battery circuit when the camera is not in use, or when a sound record is not to be made. The mechanism of this camera and its associated sound-recording appliances, are substantially the same as already described with reference to Fig. 6, etc.

Alongside of the camera. 117, is located the talking-picture projecting machine, 120, which is similar to that described with respective operative positions. From the terminal posts of the selenium grating of the projecting machine 120, are brought out the circuit wires, 122, 123, which run back to the stage as shown. A switch, 124, together with a battery 125, is also included in this circuit to enable the operator to open the battery circuit and then cut out the talking or sound reproducing instruments when these are not required. In some cases, I may also include a suitable induction coil, (not shown) in the sound reproducing circuit. Behind the screen 91, which is dropped across the stage, 100, when reproduction is going on, I arrange a series of loud-speaking telephone receivers 93, and also supplement these with additional receivers 94, which are located at the sides of the stage near the wings. These receivers, as shown, are all connected up in series by means of the wire 92, although in some cases I may, and generally prefer, to connect them in parallel circuit. In lieu of these receivers, which I have here represented as an enlarged form of the usual magneto type, I may substitute receivers of a relay or other amplifying type, such, for example, as I have illustrated in and described with respect to Fig. 1. The receivers, 93, may for convenience be mounted on a drop frame that can be lowered into position from the flies when the screen 91 is in use, while the wing receivers, 94, may be permanently attached to the proscenium arch, the framework of the boxes, 101, or other suitable point at the sides of the stage.

The operation of these devices, shown in Fig. 7, is as follows:—Let it be assumed that a grand opera, with full orchestra, and staged with all necessary scenic effects, is to be given, and is to be taken by the camera 117, for the purpose of making a photophonoscope film record of the same. The position of the singers in the cast, as distributed over the stage, 100, are indicated by the cross marks, (+) while the instruments of the orchestra. 102, are represented by the small circles (o). As will be seen, the sound-collecting board, 111, with the transmitter, 112, at its focus, is directly in front of both, and at a distance from the stage that will bring the sound-reflecting surface of the collecting board at a fairly approximate average distance of the entire audience from the performers.

Three important features connected with this part of my invention will now at once become apparent. First, the sound collecting area of the surface presented to the stage by the board 111. is many hundreds of times greater than that of a pair of human ears, and that practically the whole of this mas-

phone-transmitter 112. Second, the form and location of the concave board or "sound mirror", 111, are such as will cause it to collect and to reflect into the transmitter, 112, in segregated form vocal and instrumental sounds, overtones, consonant sounds, etc., emanating from every part of the stage and orchestra, however widely separated the singers and instruments may be, as indicated by the dotted lines and arrows showing the direction of the direct and reflected sound-waves. Third, that this arrangement entirely avoids the necessity of compactly grouping the singers and musicians, as has heretofore been the practice in the production of phonograph and gramophone records in order that as much sound as possible, might enter the phonograph horn, and also that it removes the necessity for placing the horn so close to the singers as to be in the way of photographing them. Furthermore, it eliminates the limitations hitherto placed upon such singers in the matter of having to face the phonograph while singing into it, as well as restricting their freedom of movement, both of which, or either alone, might prove fatal to the reproduction in the form of talking pictures of an operatic or dramatic performance.

With my apparatus the singers or actors are not restricted in their actions nor are they confined to a narrow area. In fact, the largest stage or arena may be covered, not only as to the sound record, but also as to the picture record. This will be manifest from an inspection of Fig. 7, in which the camera, 117, is shown at about the average distance of the audience from the stage, so that, without the necessity of employing a wide-angle lens with its unavoidable distortion effects, a natural effect will be given to the view not only of the stage settings, but of the singers and orchestral artists, the sound of whose voices and instruments, respectively, are likewise recorded, along with their accompanying motions upon the film.

It will be evident, moreover, from an inspection of Fig. 7, that the concentrated intensity of the sound waves acting upon the diaphragm of the transmitter, 112, will cause correspondingly powerful variations in the intensity of the beam of light falling upon the sound-recording portion of the film as it passes through the camera, and that this record will act more strongly upon the sound-reproducing appliances and thus be heard with greater clearness by the audience.

To still further increase the accuracy and sensitiveness of my transmitters and to reduce to a minimum the distortion of Letters Patent Nos. 777,808 and 871,787, granted me on December 20, 1904, and November 19, 1907, respectively.

The intensity of a sound of normal strength, varies inversely as the square of its distance from the ear, or in this case, from the sound-collecting board 111. In other words, a voice at the front center of the stage would affect the tansmitter 112 more strongly than the same voice would if removed to the side or rear of the stage. Now, just as the trained human ear is capable of distinguishing between and of individualizing the sounds of the separate instruments of a large orchestra, and as a less carefully trained ear is capable of detecting and separating the combined individual voices of a quartet or a sextette, and of following a single voice moving forward or across the stage, so these various composite sounds will impress themselves in the direct ratio of their varying individual qualities and intensities, upon my microphone-transmitter, and by it be faithfully recorded upon the film in the manner already described.

When my film record is reproduced, as by shifting the projecting machine, 120, shown in Fig. 7, into its central or operative position, and closing the switch, 124, the machine being set in operation, the animated picture portraying the scene and the cast are thrown upon the screen 91. Concurrently therewith the photographic sound record on the film is reproduced in the circuit wires 122, 123, and 92, in which latter are included the loud-speaking telephone receivers 93, extending across the stage behind the screen 91, and the telephone receivers, 94, in front of the screen at the extreme sides of the stage and which are pointed diagonally forward in a manner that will project the sounds therefrom onto the stage and into the auditorium without interception by the screen 91. All of these receivers, being simultaneously influenced by the same electric current, operate in perfect unison, and distribute the reproduced sounds directly upon the stage, along the length of the screen, and into the auditorium, where it is heard by the audience and by it automatically referred to the proper character represented upon the screen.

By this arrangement of my telephone-receivers, I am enabled still further to localize upon the screen the voice of any individual singer. This arrangement will enable me to heighten the effect of a solo number, as a spot-light is now used to bring an actor or singer into greater prominence, by wiring up the telephone through a commutating switch, by which the entire seven receivers

distance that the reproduced sound will have to travel, in order to secure registration between the picture and its sound in the auditorium. By the use of this simple and effective expedient, it becomes immaterial whether the voice record is taken at a point closer to the scene than the picture record, or at the same distance. It will thus be seen that my system is sufficiently flexible to lend itself to the proper taking and reproduction of every conceivable kind of subjects and under the most diverse conditions, with the assurance that either natural or absolute registration between the sound and its picture, whichever may be preferred, be secured and maintained.

Referring now to Fig. 7, this represents a plan view of part of a theater or opera-house, in which performances for my talking-pictures may be staged and in which such pictures may likewise be reproduced. In this figure, 100 represents the stage: 101, the proscenium boxes in front of the wings; 102, the space reserved for the orchestra; 103, the space occupied, below the stage level, by the orchestra seats; 104, the first or second balcony circle; 106, the space behind or over the balcony circle for the picture taking and projecting apparatus; 105 and 107, reserved spaces in the respective corners of the balcony; 108, the side walls of the auditorium; and 109, the rear or stage wall of the same.

Fixed to the front wall of the balcony, at the center thereof and in a position where it will not interfere with the view of the stage, I provide a concave sound-collecting board, 111, secured to said wall by a bracket arm 110, which extends forward and supports near its outer extremity and in such a position as to be directly in the focus of said sound collecting board, a wide-mouthed microphone-transmitter, 112. Wires 113 and 114 run from the transmitter terminals, back along the arm 110 to insulated binding posts 115 and 116, which connect by means of the transmitter circuit wires shown, with the sound-recording appliances of the picture-taking camera, 117. Included in this circuit is shown the transmitter battery 118, and a switch, 119, for opening the battery circuit when the camera is not in use, or when a sound record is not to be made. The mechanism of this camera and its associated sound-recording appliances, are substantially the same as already described with reference to Fig. 6, etc.

Alongside of the camera, 117, is located the talking-picture projecting machine, 120, which is similar to that described with reference to Figs. 1 and 2. Both these machines are mounted together upon a pair of guide rails, 121, upon which they can alternately be moved into and out of their respective positions. The terminal posts of the selenium grating of the projecting machine 120, are brought out the circuit wires, 122, 123, which run back to the stage as shown. A switch, 124, together with a battery 125, is also included in this circuit to enable the operator to open the battery circuit and then cut out the talking or sound reproducing instruments when these are not required. In some cases, I may also include a suitable induction coil, (not shown) in the sound reproducing circuit. Behind the screen 91, which is dropped across the stage, 100, when reproduction is going on, I arrange a series of loud-speaking telephone receivers 93, and also supplement these with additional receivers 94, which are located at the sides of the stage near the wings. These receivers, as shown, are all connected up in series by means of the wire 92, although in some cases I may, and generally prefer, to connect them in parallel circuit. In lieu of these receivers, which I have here represented as an enlarged form of the usual magneto type, I may substitute receivers of a relay or other amplifying type, such, for example, as I have illustrated in and described with respect to Fig. 1. The receivers, 93, may for convenience be mounted on a drop frame that can be lowered into position from the flies when the screen 91 is in use, while the wing receivers, 94, may be permanently attached to the proscenium arch, the framework of the boxes, 101, or other suitable point at the sides of the stage.

The operation of these devices, shown in Fig. 7, is as follows:—Let it be assumed that a grand opera, with full orchestra, and staged with all necessary scenic effects, is to be given, and is to be taken by the camera 117, for the purpose of making a photo-phonoscope film record of the same. The position of the singers in the cast, as distributed over the stage, 100, are indicated by the cross marks, (+) while the instruments of the orchestra, 102, are represented by the small circles (o). As will be seen, the sound-collecting board, 111, with the transmitter, 112, at its focus, is directly in front of both, and at a distance from the stage that will bring the sound-reflecting surface of the collecting board at a fairly approximate average distance of the entire audience from the performers.

Three important features connected with this part of my invention will now at once become apparent. First, the sound collecting area of the surface presented to the stage by the board 111, is many hundreds of times greater than that of a pair of human ears, and that practically the whole of this magnified sound-volume is reflected and concentrated upon a single and exceedingly sensitive mechanical ear, comprising the micro-

phone-transmitter 112. Second, the form and location of the concave board or "sound mirror", 111, are such as will cause it to collect and to reflect into the transmitter, 112, in segregated form vocal and instrumental sounds, overtones, consonant sounds, etc., emanating from every part of the stage and orchestra, however widely separated the singers and instruments may be, as indicated by the dotted lines and arrows showing the direction of the direct and reflected sound-waves. Third, that this arrangement entirely avoids the necessity of compactly grouping the singers and musicians, as has heretofore been the practice in the production of phonograph and gramophone records in order that as much sound as possible, might enter the phonograph horn, and also that it removes the necessity for placing the horn so close to the singers as to be in the way of photographing them. Furthermore, it eliminates the limitations hitherto placed upon such singers in the matter of having to face the phonograph while singing into it, as well as restricting their freedom of movement, both of which, or either alone, might prove fatal to the reproduction in the form of talking pictures of an operatic or dramatic performance.

With my apparatus the singers or actors are not restricted in their actions nor are they confined to a narrow area. In fact, the largest stage or arena may be covered, not only as to the sound record, but also as to the picture record. This will be manifest from an inspection of Fig. 7, in which the camera, 117, is shown at about the average distance of the audience from the stage, so that, without the necessity of employing a wide-angle lens with its unavoidable distortion effects, a natural effect will be given to the view not only of the stage settings, but of the singers and orchestral artists, the sound of whose voices and instruments, respectively, are likewise recorded, along with their accompanying motions upon the film.

It will be evident, moreover, from an inspection of Fig. 7, that the concentrated intensity of the sound waves acting upon the diaphragm of the transmitter, 112, will cause correspondingly powerful variations in the intensity of the beam of light falling upon the sound-recording portion of the film as it passes through the camera, and that this record will act more strongly upon the sound-reproducing appliances and thus be heard with greater clearness by the audience.

To still further increase the accuracy and sensitiveness of my transmitters and to reduce to a minimum the distortion of original characteristics of sound waves in making voice-records, I may in certain cases employ my "liquid" or "capillary" type of microphone transmitters, described in U. S. Letters Patent Nos. 777,305 and 871,787, granted me on December 20, 1904, and November 19, 1907, respectively.

The intensity of a sound of normal strength, varies inversely as the square of its distance from the ear, or in this case, from the sound-collecting board 111. In other words, a voice at the front center of the stage would affect the tansmitter 112 more strongly than the same voice would if removed to the side or rear of the stage. Now, just as the trained human ear is capable of distinguishing between and of individualizing the sounds of the separate instruments of a large orchestra, and as a less carefully trained ear is capable of detecting and separating the combined individual voices of a quartet or a sextette, and of following a single voice moving forward or across the stage, so these various composite sounds will impress themselves in the direct ratio of their varying individual qualities and intensities, upon my microphone-transmitter, and by it be faithfully recorded upon the film in the manner already described.

When my film record is reproduced, as by shifting the projecting machine, 120, shown in Fig. 7, into its central or operative position, and closing the switch, 124, the machine being set in operation, the animated picture portraying the scene and the cast are thrown upon the screen 91. Concurrently therewith the photographic sound record on the film is reproduced in the circuit wires 122, 123, and 92, in which latter are included the loud-speaking telephone receivers 93, extending across the stage behind the screen 91, and the telephone receivers, 94, in front of the screen at the extreme sides of the stage and which are pointed diagonally forward in a manner that will project the sounds therefrom onto the stage and into the auditorium without interception by the screen 91. All of these receivers, being simultaneously influenced by the same electric current, operate in perfect unison, and distribute the reproduced sounds directly upon the stage, along the length of the screen, and into the auditorium, where it is heard by the audience and by it automatically referred to the proper character represented upon the screen.

By this arrangement of my telephone-receivers, I am enabled still further to localize upon the screen the voice of any individual singer. This arrangement will enable me to heighten the effect of a solo number, as a spot-light is now used to bring an actor or singer into greater prominence, by wiring up the telephone through a commutating switch, by which the entire seven receivers shown are normally included in the circuit but are arranged so that a brush or switch-arm may be manipulated to cut in any particular one or more of these receivers alone,

which are selected according to the position of the soloist upon the screen, and, which also permits any movement of such character across the screen to be followed up telephonically in the same manner by a corresponding movement of the brush or arm, along the commutator sections or switch points. Similarly, a duet may be directly emphasized, if or while the two characters are widely separated, by the inclusion of a second receiver at the proper point on the screen. By the methods and apparatus just described, I am enabled to reproduce and present the voices and actions of a complete opera or drama with practically the same lifelike realism and thoroughness as the original performance.

The two reserved spaces 105 and 107, before mentioned, which are preferably located in opposite corners of an upper balcony where sufficient unobstructed space is available may be utilized, if required, for the placing against the walls forming said corners, of substitute or additional sound boards, 126 and 127, similar to the board 111, when either still greater sound gathering power, or special effects in recording or in reproducing the sounds, may be desired. The space available at these points generally quite large, thereby permits of the installation of sound-reflecting boards of much larger area at the proper angle to face the stage. Where these additional boards, 126, 127, are to be employed for recording purposes, however, it would not always be desirable to so utilize them without first cutting out of circuit the board 111, unless all three were located at substantially equidistant points from the center of the stage. Nor would it be desirable, except in smaller size theaters, where this would prove useful, to locate sound-collecting boards in these remote corners, 105, 107. For example, in a very large or deep theater in which a stage performance is to be taken, the distance of these corners from the stage would be so great as to cause an appreciable delay in the sound waves reaching them, which might result in causing the sound-record to lag too far behind its picture, and to overcome which would require an unduly large loop.

However, such auxiliary boards, 126, 127, may be utilized in their alternative capacity, as will presently be explained, for sound-reproducing purposes, when remotely located in large public auditoriums and other gathering places, such as opera houses, convention halls and the like,—wherein it is now extremely difficult or impossible to hear the voice of even a loud-speaker in distant galleries and other parts of the building.—tute for the transmitter 112, and place at the focus of my concave boards, a loud-speaking telephone receiver, 128, similar to those represented by the numerals 93 and 94, and directly included in the same circuit therewith, as by cutting them into the wires 122 and 123. The more or less concentrated sounds issuing from the funnels of these receivers are masked by the reversed position of these funnels with respect to the audience, thereby preventing all direct interference with the principal sounds coming from the vicinity of the screen 91. Instead, they are projected by the funnels rearwardly, directly on to the sound-reflecting surfaces of the boards 126 and 127. These boards thus reverse the preceding operation and distribute the sounds, at a suitably diminished strength, among that usually large part or section of the audience sitting at and near the rear seats and corners 105, 107 and in the upper balconies. It will therefore be seen that by means of such simultaneous and instantaneous telephonic transmission and a judicious distribution of my sound-dispersing boards, 126, 127, I am enabled clearly and audibly to project sound records, if desired, to every part of a large auditorium, so that they not only can be distinctly heard in the remotest nook and corner of the same, but in a manner that will at the same time avoid interference by echoes in halls whose acoustic properties are such as would otherwise produce them.

It will furthermore be evident that, I may also interpose or "plug in" any number of ordinary telephone receivers in my reproducing circuit, which may be used individually, by such auditors as desire them, to listen to the sound-record impressed upon the film, while viewing the picture on the screen relating thereto. I may also state here that I do not restrict or limit myself, in the use of these particular features of my invention, to the electrical distribution of sounds, through an auditorium by means of such sound-collecting and dispersing boards, or by telephones used in connection therewith from a previously formed "sound-record", but that these are likewise applicable to and intended to be used by me for the transmission and more effective distribution within the limits of an auditorium or any other place of public assembly, such for example as an out-door mass meeting, of the voice of the actual speaker or speakers who are addressing the assemblage.

Sound-collecting boards and transmitters can be placed at selected points about the enclosure when making picture and sound records of out-door events, so that records

to preserve the more natural effect or distance of the various sounds of applause, etc., I use either a single large sound-collecting board, preferably placed just above the roof of the grand stand with my transmitter at the focus, or employ two or more similar smaller boards likewise mounted near each other at the selected location, and having their respective microphone-transmitters electrically connected in parallel or series in the photophonic sound-recording circuit forming part of my camera equipment. Many novel effects may thus be produced.

Referring now to Figs. 8 to 12, inclusive, I have therein shown various typical forms of my film. In Figs. 3 and 10, the sound-record indicated by the numerals 130 and 130^a, may extend or run in a vertical direction at one side of the film, a space being reserved for this record between the right-hand sprocket perforations 132 or 132^a, and the series of pictures, 133 or 133^a. In Fig. 11, the pictures, 133, are shown as running horizontally, and the sound-record as extending in a horizontal direction below the same. The film in Fig. 9 is provided with a plurality of sound-records, two of these, 130^c and 130^d, extending along the edges of the film outside of the left and right hand sprocket holes 131^c and 132^c respectively. This location permits the use of the existing standard size of motion-picture films without diminution of the size of the pictures, and also shows how photographic sound-records may be impressed upon those portions of the film not at present utilized. These sound records may be of any desired width varying all the way from a fine line, as indicated in Fig. 9, to a narrow ribbon or band, as in Fig. 10, according to the size of the light-opening in the recording cap 34 of Fig. 6.

Fig. 10 shows an extra wide film useful in taking and reproducing performances, on a large scale, in which the entire stage, either with or without its proscenium arch as a frame for the setting, may be shown. This film also has an extra wide space for my sound-record, in order to give it ample capacity for the reception and proper reproduction of the powerful sound vibrations of a large chorus and orchestra as well as for reducing the average light intensity when desired to attain the degree best adapted to photographing sound.

The purpose of the arrangement in Fig. 11 is to minimize the objectionable flickering of the ordinary film and the reduction of illumination caused by the use of a shutter, and thus to bring about a superior picture

rately, jointly, or cut out altogether. Two light-tight reproducing tubes, 135 and 135, each of the general type of that shown in Fig. 2, and corresponding with the hood section, 61, in that figure, are provided with small light-openings, 36, that register with their respective sound records. A manually-operated slide, 136, provided with a series of notches, 137, that cooperate with a spring detent, 138, fastened at one end to the outside of right-hand reproducing tube 135, passes through suitable guide slots in the walls of the tubes 135, and 135. The slide 136 is provided with two elongated exposure slots, 139, through which light from the lamp may pass and enter the aperture or apertures 36, when either or both are exposed, and thus cause the audible reproduction of either or both of said records, according to the position of the slide 136 as indicated by the scale shown at the right hand end thereof. It will likewise be obvious that by this arrangement either one or both of the sound records 130^c, 130^d, carried by the film 1, can be reproduced without at the same time reproducing the accompanying picture record 133, by the simple expedient of screening or cutting off the light from the picture projecting lamp, and also that any one or more of a number of parallel sound-records contained on my talking films may be separately or jointly reproduced, as desired, by a proper disposition of the exposure openings in the slide 136, or its equivalent.

When my films are provided with but a single sound-record, as shown for example, in connection with the type of picture represented in Fig. 8, such sound record need not necessarily be one produced by the voice, nor one directly related to the characters portrayed. It may, instead, consist of some instrumental or orchestral selection appropriate to the act or scene represented by the pictures. In this and other pantomime representations, the appropriate musical selection is a matter of choice and would be merely incidental and serve to add to the effectiveness of the subject exhibited, without necessarily being in synchronism therewith.

To facilitate the reproduction of multiple sound-records, the tubes, 135, are preferably given a slight lateral adjustment, by which the light-openings, 36, may be shifted into alignment with the desired record. In a camera designed for the simultaneous taking of a plurality of individual sound records, a corresponding number of lamps, or sources of light may be employed, and these lamps and their associated projecting lens-

which are selected according to the position of the soloist upon the screen, and, which also permits any movement of such character across the screen to be followed up telephonically in the same manner by a corresponding movement of the brush or arm, along the commutator sections or switch points. Similarly, a duet may be directly emphasized, if or while the two characters are widely separated, by the inclusion of a second receiver at the proper point on the screen. By the methods and apparatus just described, I am enabled to reproduce and present the voices and actions of a complete opera or drama with practically the same lifelike realism and thoroughness as the original performance.

The two reserved spaces 105 and 107, before mentioned, which are preferably located in opposite corners of an upper balcony where sufficient unobstructed space is available may be utilized, if required, for the placing against the walls forming said corners, of substitute or additional sound boards, 126 and 127, similar to the board 111, when either still greater sound gathering power, or special effects in recording or in reproducing the sounds, may be desired. The space available at these points generally quite large, thereby permits of the installation of sound-reflecting boards of much larger area at the proper angle to face the stage. Where these additional boards, 126, 127, are to be employed for recording purposes, however, it would not always be desirable to so utilize them without first cutting out of circuit the board 111, unless all three were located at substantially equidistant points from the center of the stage. Nor would it be desirable, except in smaller size theaters, where this would prove useful, to locate sound-collecting boards in these remote corners, 105, 107. For example, in a very large or deep theater in which a stage performance is to be taken, the distance of these corners from the stage would be so great as to cause an appreciable delay in the sound waves reaching them, which might result in causing the sound-record to lag too far behind its picture, and to overcome which would require an unduly large loop.

However, such auxiliary boards, 126, 127, may be utilized in their alternative capacity, as will presently be explained, for sound-reproducing purposes, when remotely located in large public auditoriums and other gathering places, such as opera houses, convention halls and the like,—wherein it is now extremely difficult or impossible to hear the voice of even a loud-speaker in distant galleries and other parts of the building,—and the arrangement indicated will be found highly effective and useful. In this application of auxiliary boards, I substitute for the transmitter 112, and place at the focus of my concave boards, a loud-speaking telephone receiver, 128, similar to those represented by the numerals 93 and 94, and directly included in the same circuit therewith, as by cutting them into the wires 122 and 123. The more or less concentrated sounds issuing from the funnels of these receivers are masked by the reversed position of these funnels with respect to the audience, thereby preventing all direct interference with the principal sounds coming from the vicinity of the screen 91. Instead, they are projected by the funnels rearwardly, directly on to the sound-reflecting surfaces of the boards 126 and 127. These boards thus reverse the preceding operation and distribute the sounds, at a suitably diminished strength, among that usually large part or section of the audience sitting at and near the rear seats and corners 105, 107 and in the upper balconies. It will therefore be seen that by means of such simultaneous and instantaneous telephonic transmission and a judicious distribution of my sound-dispersing boards. 126, 127, I am enabled clearly and audibly to project sound records, if desired, to every part of a large auditorium, so that they not only can be distinctly heard in the remotest nook and corner of the same, but in a manner that will at the same time avoid interference by echoes in halls whose acoustic properties are such as would otherwise produce them.

It will furthermore be evident that, I may also interpose or "plug in" any number of ordinary telephone receivers in my reproducing circuit. which may be used individually, by such auditors as desire them, to listen to the sound-record impressed upon the film, while viewing the picture on the screen relating thereto. I may also state here that I do not restrict or limit myself, in the use of these particular features of my invention, to the electrical distribution of sounds, through an auditorium by means of such sound-collecting and dispersing boards, or by telephones used in connection therewith from a previously formed "sound-record", but that these are likewise applicable to and intended to be used by me for the transmission and more effective distribution within the limits of an auditorium or any other place of public assembly, such for example as an out-door mass meeting, of the voice of the actual speaker or speakers who are addressing the assemblage.

Sound-collecting boards and transmitters can be placed at selected points about the enclosure when making picture and sound records of out-door events, so that records of sounds originating at these points may be impressed separately or collectively upon the film. If instead, it be preferred

to preserve the more natural effect or distance of the various sounds of applause, etc., I use either a single large sound-collecting board, preferably placed just above the roof of the grand stand with my transmitter at the focus, or employ two or more similar smaller boards likewise mounted near each other at the selected location, and having their respective microphone-transmitters electrically connected in parallel or series in the photophonic sound-recording circuit forming part of my camera equipment. Many novel effects may thus be produced.

Referring now to Figs. 8 to 12, inclusive, I have therein shown various typical forms of my film. In Figs. 3 and 10, the sound-record indicated by the numerals 130 and 130^a, may extend or run in a vertical direction at one side of the film, a space being reserved for this record between the right-hand sprocket perforations 132 or 132^a, and the series of pictures, 133 or 133^a. In Fig. 11, the pictures, 133, are shown as running horizontally, and the sound-record as extending in a horizontal direction below the same. The film in Fig. 9 is provided with a plurality of sound-records, two of these, 130^c and 130^d, extending along the edges of the film outside of the left and right hand sprocket holes 131^c and 132^c respectively. This location permits the use of the existing standard size of motion-picture films without diminution of the size of the pictures, and also shows how photographic sound-records may be impressed upon those portions of the film not at present utilized. These sound records may be of any desired width varying all the way from a fine line, as indicated in Fig. 9, to a narrow ribbon or band, as in Fig. 10, according to the size of the light-opening in the recording cap 34 of Fig. 6.

Fig. 10 shows an extra wide film useful in taking and reproducing performances, on a large scale, in which the entire stage, either with or without its proscenium arch as a frame for the setting, may be shown. This film also has an extra wide space for my sound-record, in order to give it ample capacity for the reception and proper reproduction of the powerful sound vibrations of a large chorus and orchestra as well as for reducing the average light intensity when desired to attain the degree best adapted to photographing sound.

The purpose of the arrangement in Fig. 11 is to minimize the objectionable flickering of the ordinary film and the reduction of illumination caused by the use of a shutter, and thus to bring about a superior picture as well as sound reproduction.

In Fig. 9 I have shown means by which the left and right hand sound records, 130^c and 130^d, may at will be reproduced separately, jointly, or cut out altogether. Two light-tight reproducing tubes, 135 and 135, each of the general type of that shown in Fig. 2, and corresponding with the hood section, 61, in that figure, are provided with small light-openings, 36, that register with their respective sound records. A manually-operated slide, 136, provided with a series of notches, 137, that cooperate with a spring detent, 138, fastened at one end to the outside of right-hand reproducing tube 135, passes through suitable guide slots in the walls of the tubes 135, and 135. The slide 136 is provided with two elongated exposure slots, 139, through which light from the lamp may pass and enter the aperture or apertures 36, when either or both are exposed, and thus cause the audible reproduction of either or both of said records, according to the position of the slide 136 as indicated by the scale shown at the right hand end thereof. It will likewise be obvious that by this arrangement either one or both of the sound records 130^c, 130^d, carried by the film 1, can be reproduced without at the same time reproducing the accompanying picture record, 133, by the simple expedient of screening or cutting off the light from the picture projecting lamp, and also that any one or more of a number of parallel sound-records contained on my talking films may be separately or jointly reproduced, as desired, by a proper disposition of the exposure openings in the slide 136, or its equivalent.

When my films are provided with but a single sound-record, as shown for example, in connection with the type of picture represented in Fig. 8, such sound record need not necessarily be one produced by the voice, nor one directly related to the characters portrayed. It may, instead, consist of some instrumental or orchestral selection appropriate to the act or scene represented by the pictures. In this and other pantomime representations, the appropriate musical selection is a matter of choice and would be merely incidental and serve to add to the effectiveness of the subject exhibited, without necessarily being in synchronism therewith.

To facilitate the reproduction of multiple sound-records, the tubes, 135, are preferably given a slight lateral adjustment, by which the light-openings, 36, may be shifted into alignment with the desired record. In a camera designed for the simultaneous taking of a plurality of individual sound records, a corresponding number of lamps, or sources of light may be employed, and these lamps and their associated projecting lens-tubes are located beneath one another with their centers slightly displaced in a direction transverse to the direction of travel of the film.

The various records on the film may just as readily be reproduced simultaneously in one or more languages to different sections of the auditorium reserved for those understanding the respective languages.

I do not claim herein the recording method or the method of producing combined motion picture and sound records as that part of my invention is the subject matter of divisional application Serial No. 630,197, filed April 6, 1923 (Patent No. 1,473,976, dated November 13, 1923); nor do I claim herein the recording apparatus as that part of my invention is the subject matter of divisional application Serial No. 637,365, filed May 7, 1923; nor do I claim herein the reproducing apparatus as that part of my invention is the subject matter of divisional application Serial No. 633,907, filed April 23, 1923; nor do I claim herein the photographic record per se as that part of my invention is the subject matter of divisional application Serial No. 633,908, filed April 23, 1923; nor do I claim herein the method and installation for producing and for reproducing records in large auditoriums or out-door places as that part of my invention is the subject matter of divisional application Serial No. 633,909, filed April 23, 1923.

Having thus described my invention I claim as new and desire to secure by Letters Patent:—

1. The method of reproducing a sonorous action previously recorded on a photographic film as a band the translucency of which varies along the length thereof with the amplitudes of air vibrations corresponding to the original sonorous action; which method consists in moving the photographic film behind a screen having a small aperture in alignment with the record band, projecting a beam of light of constant intensity through such aperture, restricting the area of the record band exposed to such light to the area of said aperture, and interposing a light-sensitive electric resistance material in an electric circuit, to intercept the light transmitted through the film, whereby the variations in translucency of the photographic record will produce corresponding variations in said electric circuit.

2. The method of sound reproduction which consists in transmitting light of substantially constant intensity through a highly restricted aperture and spreading the transmitted light over a light sensitive electric resistance of relatively large area in an electric circuit, while interposing seriatim in the path of such light successive parts of a sound record, the translucency of which at successively interposed parts corresponds to the successive density and attenuation of the air vibrations accompanying the original sonorous action, restricting the area of exposure of such record as it moves through the beam of light to the area of said aperture, and causing the variations produced in said electric circuit through the variations in translucency of said sound record to be impressed upon a sound amplifying device.

3. The method of sound reproduction which consists in transmitting light of substantially constant intensity through a highly restricted aperture and spreading the transmitted beam of light over a light sensitive electric resistance of relatively large area in an electric circuit, while moving a sound record, the translucency of which varies with the direction of movement thereof in accordance with the density and attenuation of the air vibrations accompanying the original sonorous action, through said beam of light, and limiting the area of exposure of such record to the area of said aperture, whereby the variations in translucency of the photographic record will produce corresponding variations in said electric circuit.

4. The method of sound reproduction which consists in passing light of substantially constant intensity through a small window aperture in a screen and spreading the emerging transmitted light substantially uniformly over a light sensitive electric resistance of relatively large area in a telephonic circuit, while introducing a light absorbing medium adjacent the aperture, varying in translucency in accordance with the amplitudes of air vibrations accompanying the original sonorous action, and restricting the area of exposure of such medium to the area of said aperture.

5. The method of sound reproduction which consists in focusing light of substantially constant intensity or candle power through a small window aperture in a fixed screen upon a contiguous moving sound record having translucencies which vary as successive portions thereof are exposed to the light in accordance with the amplitude of air vibrations accompanying the original sonorous action, restricting the area of exposure of the sound record to the area of the aperture, and spreading the residual light transmitted through the record upon a light sensitive resistance material having relatively large cross-section in an electric circuit.

Signed at New York, in the county of New York and State of New York this 20th day of May, A. D. 1913.

ELIAS E. RIES.

1250

April 23, 1929. A. J. CAWLEY 1,710,677

PICTURE NEGATIVE

Original Filed Oct. 3, 1919

Fig 1.

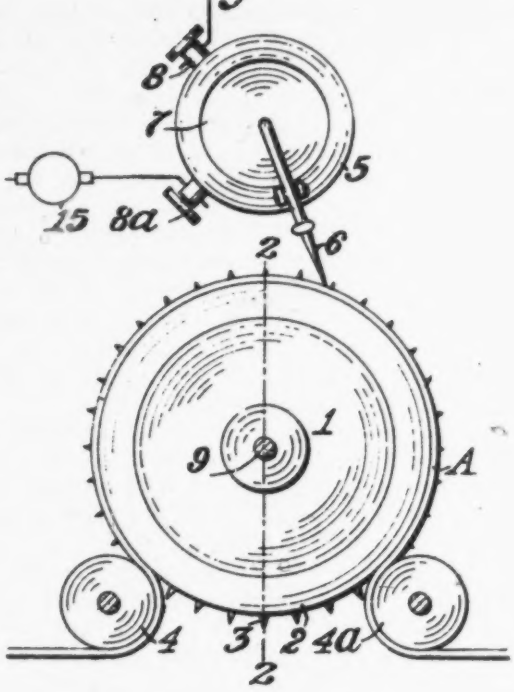


Fig 2.

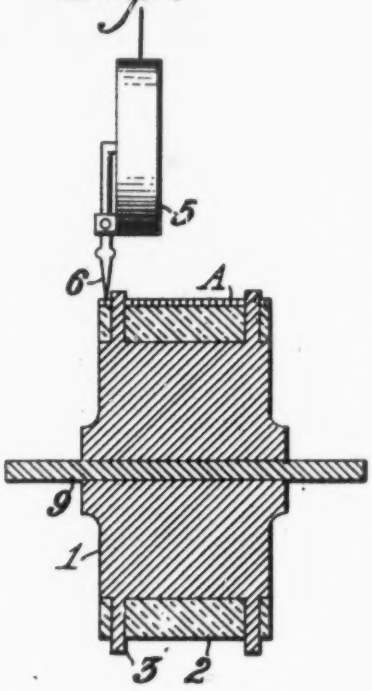


Fig 3.

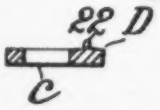
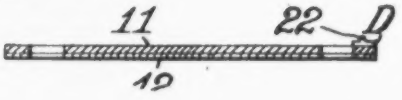


Fig 4.



INVENTOR

Alonzo J. Cawley

Patented Apr. 23, 1929. 1,710,677

UNITED STATES PATENT OFFICE.

ALOYSIUS J. CAWLEY, OF PITTSTON, PENNSYLVANIA.

PICTURE NEGATIVE.

Original application filed October 3, 1919, Serial No. 328,299. Divided and this application filed August 2, 1926. Serial No. 126,648.

This application is a division of my application for a process of laterally modifying a sound record, Serial Number 328,299, filed October 3, 1919, which covered a process of photographically magnifying sound records, preferably those produced on motion picture films, being a complete record of the movements and sounds of persons or objects. By the above process, the length of the sound record was not altered in the least.

Either from the laterally enlarged sound record, or from an unaltered original sound record groove, a linear ribbon-like patrix was made by passing the record through the interval between rolls while in contact with a suitable soft metal strip, and applying suitable pressure. The patrix could also be produced by electrochemical means. This patrix was cemented to the margin of the original negative motion picture film, thus forming a complete talking picture negative record, from which thousands of duplicates could be made in a very short time.

This talking picture negative was run through a combined motion picture printer and sound record molder, producing thereby any number of finished talking picture positives, i. e., motion picture films bearing preferably on their margins, their own synchronous sound records.

In either imprinting a mechanical groove record on a motion picture film, thus forming its sound record, or in reproducing one of the complete talking picture positives, consisting of a photographic picture record and its corresponding synchronous sound record, as mentioned in the last paragraph, a special type of motion picture sprocket wheel, having a portion of its structure made of sound record backing material was used. This constituted a veritable phonographic cylindrical record, which is capable of the most faithful reproduction.

For a more complete understanding of the invention, reference is to be had to the following descriptions and claims taken in connection with the accompanying drawings, which illustrate certain embodiments of the invention, and wherein similar reference characters are employed to designate corresponding parts throughout the several views, and in which:

Figure 1 is a side view of a device for reproducing of sound records of the mechanical groove type on motion picture films.

Figure 2 is a cross-sectional view of the sprocket wheel on the line 2—2, the reproducer not being shown itself in cross-section.

Figure 3 is a cross-sectional view of one of the several types of patrices which the invention covers.

Figure 4 is a cross-sectional view of a negative motion picture film with its corresponding sound record patrix cemented to its margin. This greatly facilitates the simultaneous printing and impressing of picture and sound record respectively.

In the recording or reproducing of sound records in practice, it is highly desirable that the film should be held perfectly rigid while moving at an absolutely uniform rate of speed. Figure 1 is an end view of a device, which may form a part of the camera or projector, and intended to accomplish this object.

It illustrates a motion picture film upon which has been impressed a sound record groove of the synchronized sounds of the objects photographed on the film, passing through the projector and engaged by a stylus which is attached to the diaphragm of a microphone in order to impress the fluctuations corresponding to the sound record upon the electric current which traverses the microphone. This current in turn operates a loud speaking telephone located behind the projection screen. The projector is not shown in its entirety, but in accordance with the rules of the office, only the part of the projector with which the stylus cooperates, and which is here shown as the sprocket wheel adjacent the projector film gate. Obviously, a specially designed reproducer sprocket may be inserted at any part of the projector mechanism desired. This sprocket wheel is mounted on shaft 9 of the projector. The positive film A is held in firm contact with this sprocket wheel 1, which is provided with a resilient ring 2. This may be made of hard rubber, which in turn may be coated with a rubber paint on its surface. It may be also made of any phonographic record backing material, or, it may be made of

April 23, 1929. A. J. CAWLEY 1,710,677

PICTURE NEGATIVE

Original Filed Oct. 3, 1919

Fig 1.

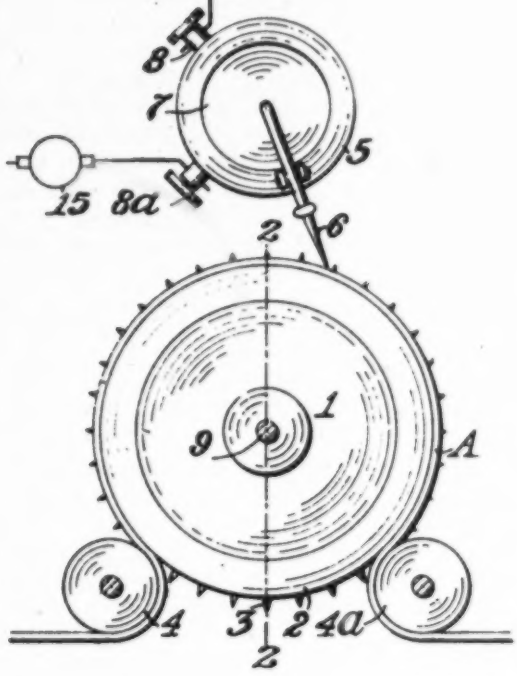


Fig 2.

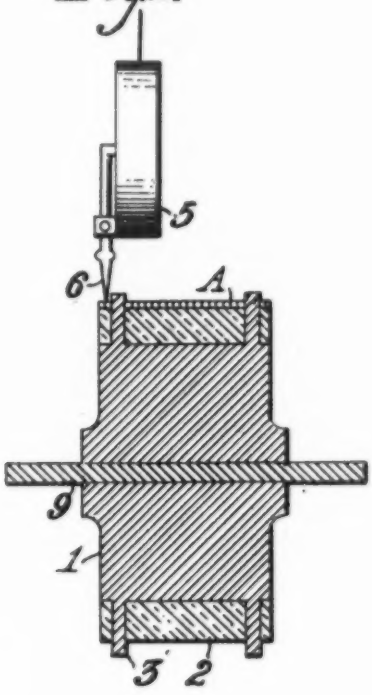


Fig 3.

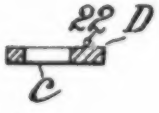


Fig 4.

INVENTOR

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PICTURE NEGATIVE.

Original application filed October 3, 1919, Serial No. 328,299. Divided and this application filed August 2, 1926. Serial No. 126,648.

This application is a division of my application for a process of laterally modifying a sound record, Serial Number 328,299, filed October 3, 1919, which covered a process of photographically magnifying sound records, preferably those produced on motion picture films, being a complete record of the movements and sounds of persons or objects. By the above process, the length of the sound record was not altered in the least.

Either from the laterally enlarged sound record, or from an unaltered original sound record groove, a linear ribbon-like patrix was made by passing the record through the interval between rolls while in contact with a suitable soft metal strip, and applying suitable pressure. The patrix could also be produced by electrochemical means. This patrix was cemented to the margin of the original negative motion picture film, thus forming a complete talking picture negative record, from which thousands of duplicates could be made in a very short time.

This talking picture negative was run through a combined motion picture printer and sound record molder, producing thereby any number of finished talking picture positives, i. e., motion picture films bearing preferably on their margins, their own synchronous sound records.

In either imprinting a mechanical groove record on a motion picture film, thus forming its sound record, or in reproducing one of the complete talking picture positives, consisting of a photographic picture record and its corresponding synchronous sound record, as mentioned in the last paragraph, a special type of motion picture sprocket wheel, having a portion of its structure made of sound record backing material was used. This constituted a veritable phonographic cylindrical record, which is capable of the most faithful reproduction.

For a more complete understanding of the invention, reference is to be had to the following descriptions and claims taken in connection with the accompanying drawings, which illustrate certain embodiments of the invention, and wherein similar reference characters are employed to designate corresponding parts.

Figure 1 is an end view of the specially designed sprocket wheel, which is intended to accomplish a more perfect recording or reproducing of sound records of the mechanical groove type on motion picture films.

Figure 2 is a cross-sectional view of the sprocket wheel on the line 2—2, the reproducer not being shown itself in cross-section.

Figure 3 is a cross-sectional view of one of the several types of patrices which the invention covers.

Figure 4 is a cross-sectional view of a negative motion picture film with its corresponding sound record patrix cemented to its margin. This greatly facilitates the simultaneous printing and impressing of picture and sound record respectively.

In the recording or reproducing of sound records in practice, it is highly desirable that the film should be held perfectly rigid while moving at an absolutely uniform rate of speed. Figure 1 is an end view of a device, which may form a part of the camera or projector, and intended to accomplish this object.

It illustrates a motion picture film upon which has been impressed a sound record groove of the synchronized sounds of the objects photographed on the film, passing through the projector and engaged by a stylus which is attached to the diaphragm of a microphone in order to impress the fluctuations corresponding to the sound record upon the electric current which traverses the microphone. This current in turn operates a loud speaking telephone located behind the projection screen. The projector is not shown in its entirety, but in accordance with the rules of the office, only the part of the projector with which the stylus cooperates, and which is here shown as the sprocket wheel adjacent the projector film gate. Obviously, a specially designed reproducer sprocket may be inserted at any part of the projector mechanism desired. This sprocket wheel is mounted on shaft 9 of the projector. The positive film A is held in firm contact with this sprocket wheel 1, which is provided with a resilient ring 2. This may be made of hard rubber, which in turn may be coated with a rubber paint on its surface. It may be also made of any phonographic record backing material, or, it may be made of any of the following substances: ebonite, wax, shellac, paper or earthy composition.

Two rings extend upward from the steel body of the sprocket wheel through this

ring, or cushion, to form a base for the sprocket teeth. When the film is passed around this wheel and its perforations properly engaged with the sprocket teeth, the whole constitutes almost the exact equivalent of a cylindrical phonographic record on its mandrel. Thus the unsatisfactory reproduction from the frail film alone is done away with. The stylus, shown at 6, and the reproducer, which is shown as a microphone 7, are contained in the sound box 5. The electric power is shown as being supplied by 15, which may be a direct current dynamo, or storage battery, as it is desired to obtain a loud, powerful, reproduction. The wires from binding posts 8 and 8ª lead to a loud speaking telephone receiver located near or behind the picture screen. An induction coil may be included in the circuit which contains vacuum tube amplifying circuits, in order to increase the sound intensity. The contact rolls 4 and 4ª hold the film in contact. This type of sprocket wheel is intended for either recording or reproducing of sounds.

After printing the picture record and impressing the sound record from the patrix in one operation by means of the device described in the above mentioned application, I have produced a positive motion picture or talking picture film.

The patrix may be made in any way desired. It may be made directly from a sound record groove; or a photosensitive strip, printed from the original photographic sound record may be subjected to different treatments so that either a ridge or a groove is produced. If the original record was a groove, a patrix may be made from it directly by means of pressure. For instance, a bichromated gelatine strip is treated with old water, causing a ridge to swell upon its surface. This may be hardened by chrome alum, tannic acid, formalin, alum, or similar substance. It may be used directly as a patrix.

If a silver haloid strip be used, the silver line may be built up chemically, so as to form a raised ridge, and this used directly as a patrix.

The bichromated gelatine may be treated with warm water, and the unaltered material dissolved out, and a groove produced. If a silver haloid strip is used, the metallic silver of the record line is dissolved by chemical treatment, for instance with nitric acid. In either case, after thoroughly drying and hardening the strip, it is placed in contact with a ribbon of soft metal, such as lead, and pressure applied by rolls, or the like, and a metallic patrix D, Figure 3, having a ridge 22 is obtained. This patrix may be used to impress the sound record on the positive films. This patrix may be provided with sprocket holes to engage with the sprocket teeth. Those holes are shown at *c* of Figure 3.

In practice, many positives are produced from the same negative. In order to facilitate this, and also to furnish convenience in handling and storing, and to avoid errors in printing sound and picture records in proper register, the patrix D is cemented to the negative film margin, as shown in Figure 4. The extreme utility of this is very apparent. Figure 4 illustrates the film 11 with its photographic record 12 and sound record patrix 22 formed on metallic strip D cemented to its margin. This constitutes what is literally a talking picture negative. Talking picture positives are made from it at the same speed that an ordinary motion picture film is printed by use of the combined picture printer and sound record molder described in the above mentioned application.

Having described my invention, I claim as new and desire to secure by Letters Patent.

1. A talking picture negative, consisting of a film bearing a negative photographic motion picture record and a patrix coextensive with said negative motion picture record and formed from a sound record which is a synchronized accompaniment of said picture record attached to said film capable of impressing the corresponding sound record.

2. A talking picture negative, consisting of a film bearing a negative photographic record of the movements of persons or objects, and a patrix coextensive with said negative photographic record and formed from a sound record which is a synchronized accompaniment of said picture record attached to said film capable of impressing the synchronous sound record of sounds emitted by said persons or objects.

3. A talking picture negative, consisting of a film bearing a negative photographic record of the movements of persons or objects, and a patrix coextensive with said negative photographic record and formed from a sound record which is a synchronized accompaniment of said picture record attached to said film capable of impressing a record of sounds emitted by said persons or objects, said records of movements and sounds being capable of synchronous reproduction.

Philadelphia, Pa., July 14, 1926.

ALOYSIUS J. CAWLEY.

1254

Sept. 29, 1931. A. J. CAWLEY 1,825,438

PHOTO ELECTRIC SOUND RECORDING OR REPRODUCING

Filed Sept. 16, 1929 2 Sheets-Sheet 1

Fig. 1

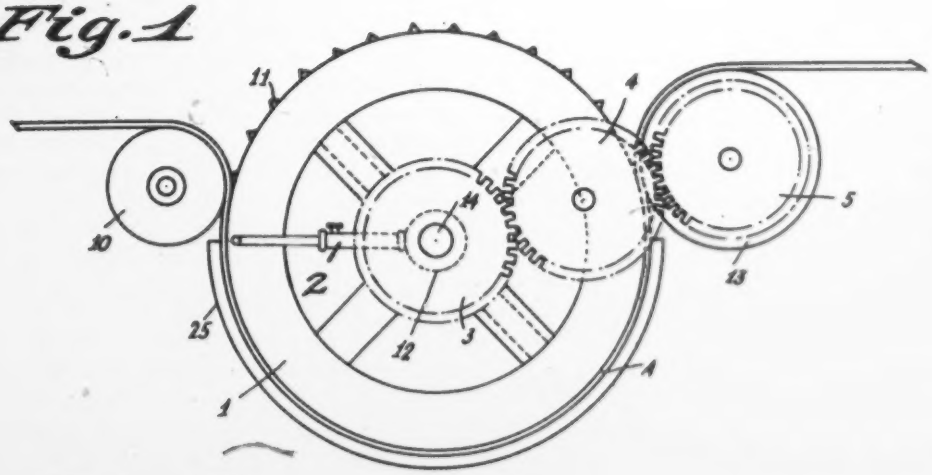


Fig. 2

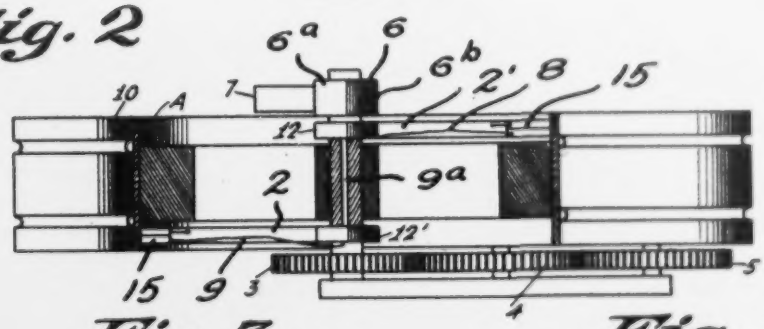


Fig. 3

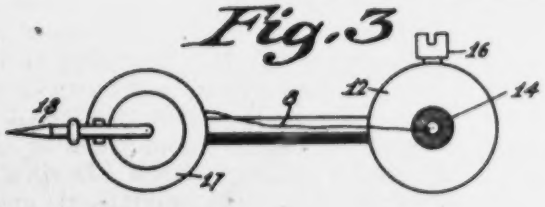


Fig. 4

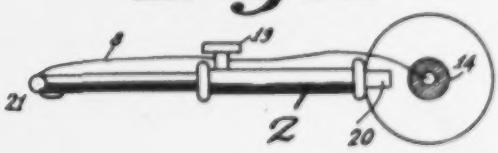


Fig. 5

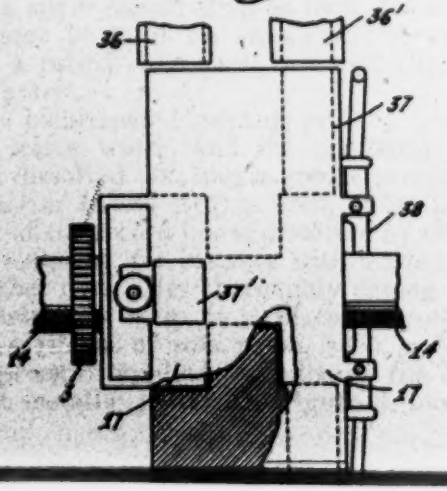
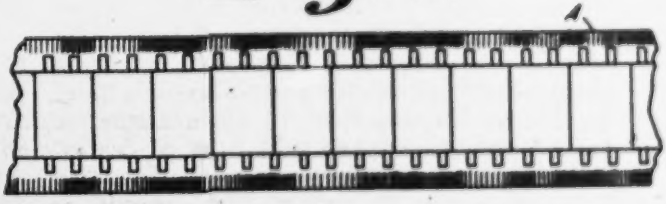


Fig. 6



INVENTOR
ALOYSIUS J. CAWLEY

Sept. 29, 1931. A. J. CAWLEY 1,825,438

PHOTO ELECTRIC SOUND RECORDING OR REPRODUCING

Filed Sept. 16, 1929 2 Sheets-Sheet 1

Fig. 1

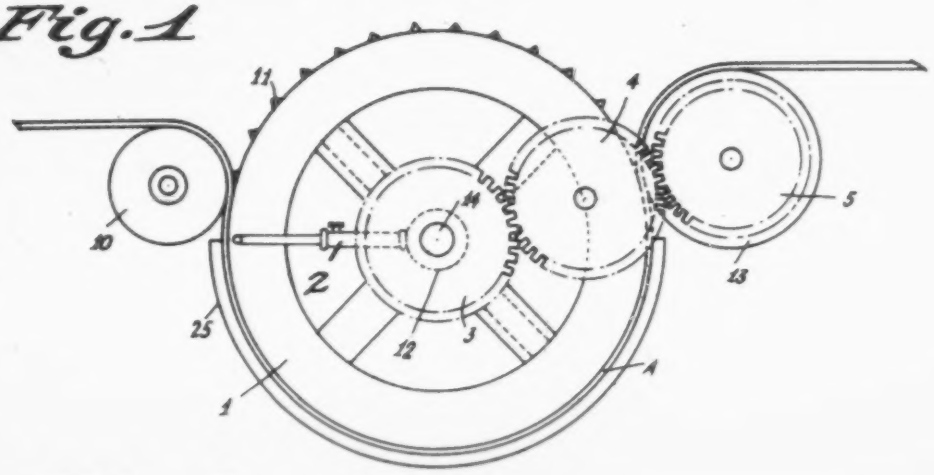


Fig. 2

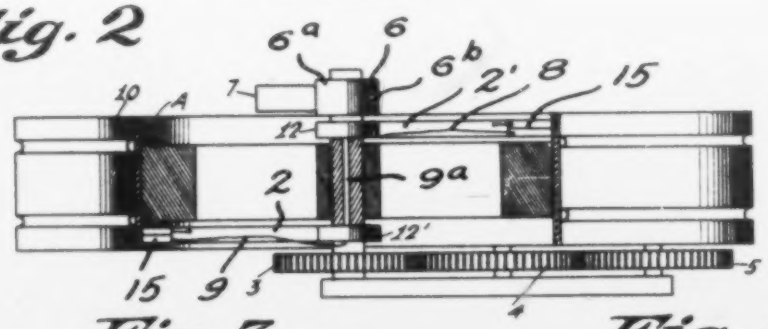


Fig. 3

Fig. 4

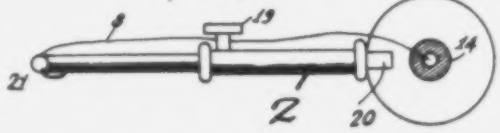


Fig. 5

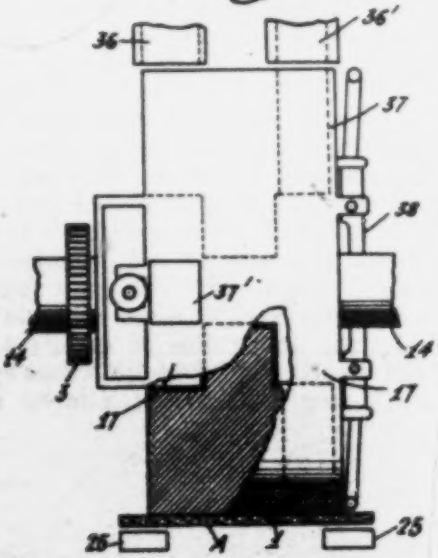
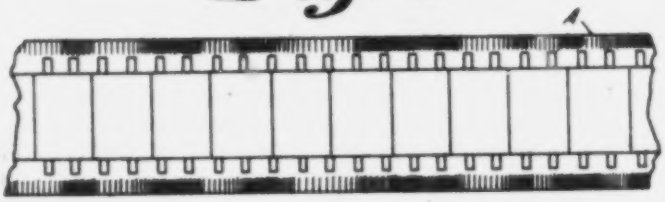


Fig. 6



INVENTOR
ALOYSIUS J. CAWLEY
BY W. T. Grover
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1256

Sept. 29, 1931. A. J. CAWLEY 1,825,438

PHOTO ELECTRIC SOUND RECORDING OR REPRODUCING

Filed Sept. 16, 1929 2 Sheets-Sheet 2

Fig. 7

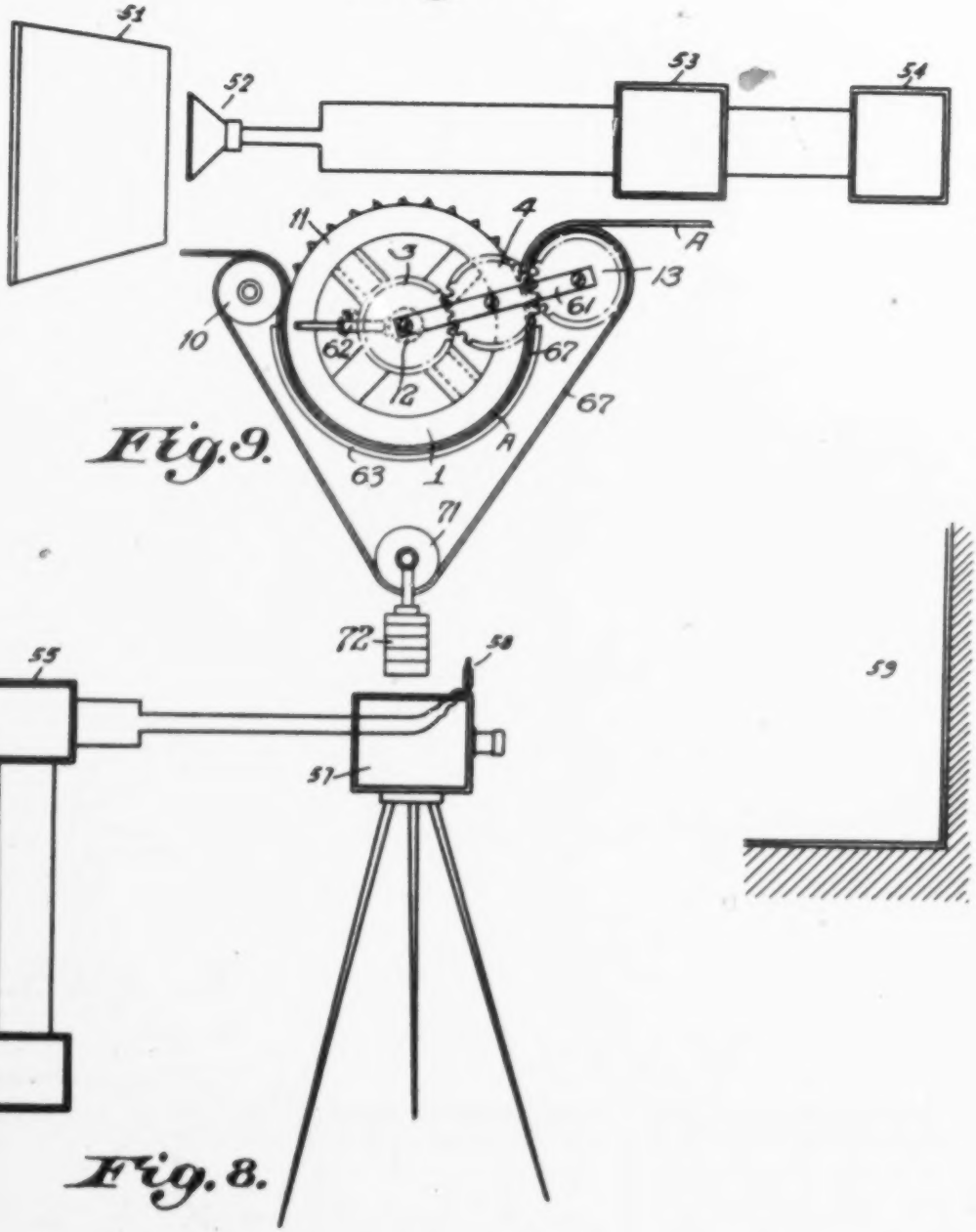

Fig. 9.

Fig. 8.

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Patented Sept. 29, 1931

1,825,438

1257

UNITED STATES PATENT OFFICE

ALOYSIUS J. CAWLEY, OF PITTSTON, PENNSYLVANIA, ASSIGNOR TO RADIO CORPORATION OF AMERICA, A CORPORATION OF DELAWARE

PHOTO-ELECTRIC SOUND RECORDING OR REPRODUCING

Original application filed January 8, 1921, Serial No. 435,984. Divided and this application filed September 16, 1929. Serial No. 393,071.

This application is a division of my application Serial No. 435,984 filed January 8, 1921.

The invention relates generally to the method of producing sound records on motion picture films, so that sound and picture records may be synchronously reproduced, although the invention is not necessarily limited to this field.

More particularly the invention is concerned with the recording optically or reproduction of sound photo-electrically on motion picture film.

Arrangements are described whereby any desired sound recording speed may be obtained without any increase in the speed of the film, by simply increasing the number and speed of the recording units.

The invention is perfectly adaptable to the standard motion picture film as it exists in practice at present, and is concerned with placing sound records on the margin, or margins of such a film. This is particularly feasible if photographic sound records are used. The latter may be placed on one margin only, or be distributed on both margins, as hereinafter described.

As the sound records are intended to be placed at the margins of the film, there is no interference of picture and sound record as would be the case, if for instance, the latter were placed across the reverse face of the film, as in such case, they would be projected upon the picture screen.

The invention, further, is not limited to photographic methods of recording or photo-electric reproduction but is adapted to any mechanical, magnetic, or electric reproduction described in my parent application and the related divisions thereof. Although the invention is not limited to any of those methods, great emphasis is placed on the method employing the photo-electric reproduction and photographic recording.

It will be noted that there are no abrupt changes in the direction of moving parts. All parts move in a unif[illegible] film carrier nor the recorders move at this speed, the high speed mentioned being due to the relative motion of recorder and film. This means that considerable wear is saved in the apparatus.

One can readily see that by employing a suitable number of recorders moving at a proper speed, photographic sound recording processes requiring a speed of six feet per second may be utilized so that they may be placed on a film that is moving at the standard motion picture speed of one foot per second.

For a more complete understanding of the invention, reference is to be had to the following description and claims taken in connection with the accompanying drawings, in which like characters of reference denote corresponding parts in all the views, and in which,

Figure 1 is an elevational view showing a photographic recording or photo-electric reproducing device.

Figure 2 is a cross sectional view on line BC of the rotating film carrier.

Figure 3 is an elevational view of an electrically operated, mechanical sound recorder placed on a radial arm.

Figure 4 is a plan view of a photographic sound recorder placed on a radial arm, also illustrating the detachable nature of the latter.

Figure 5 is a side elevation of the wheel of Fig. 1 showing the film thereon.

Figure 6 is a view of the film used.

Figure 7 is a diagrammatic illustration of a sound reproducer installation in conjunction with a projection screen.

Figure 8 is a diagrammatic illustration of a recording apparatus as arranged for operation.

Figure 9 corresponds to Figure 1, but shows an additional means for maintaining the film in intimate contact with the wheel.

There are many ways of carrying out the invention, and although certain structures

PHOTO ELECTRIC SOUND RECORDING OR REPRODUCING

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Fig. 7

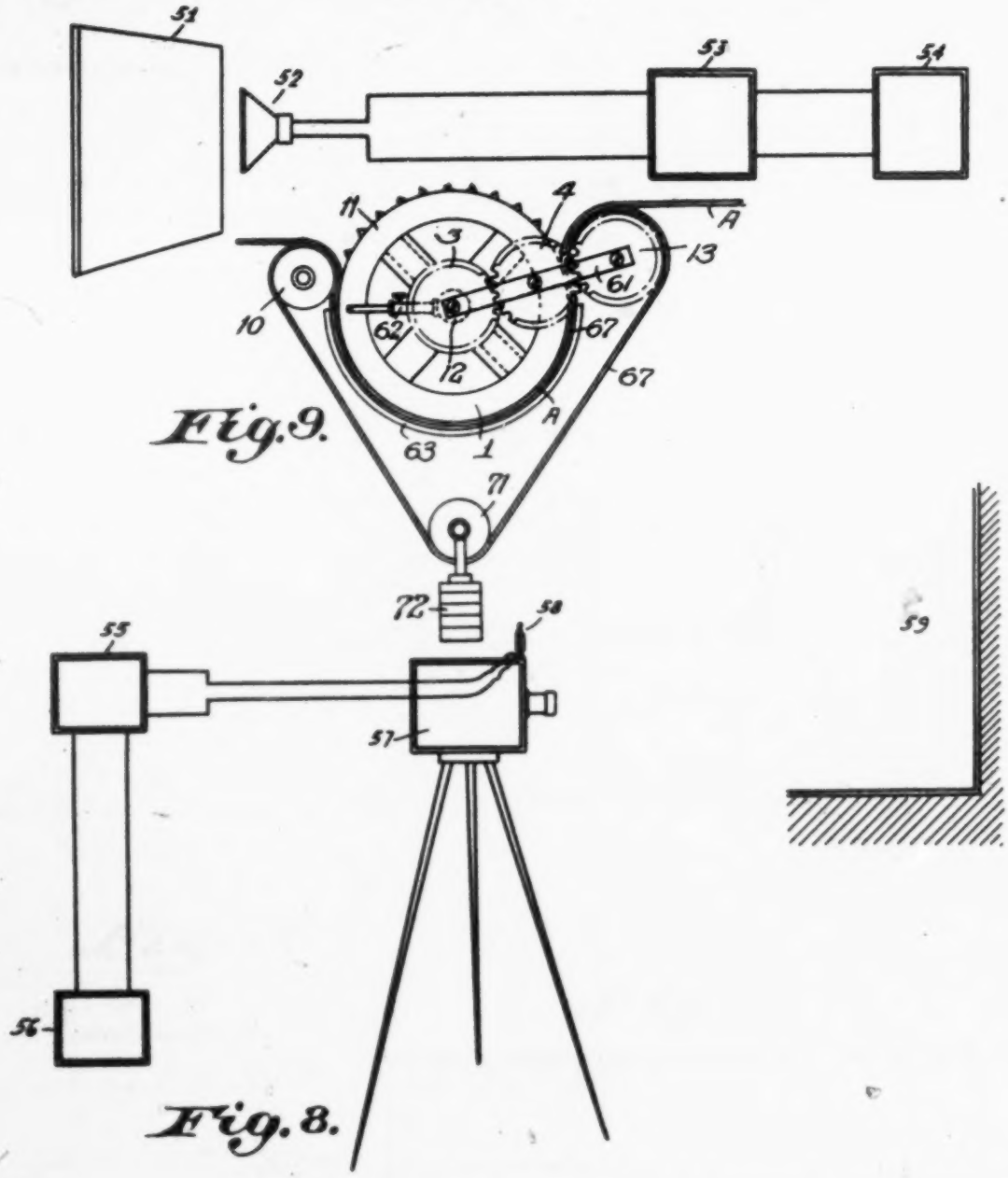

Fig. 9.

Fig. 8.

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Arrangements are described whereby any desired sound recording speed may be obtained without any increase in the speed of the film, by simply increasing the number and speed of the recording units.

The invention is perfectly adaptable to the standard motion picture film as it exists in practice at present, and is concerned with placing sound records on the margin, or margins of such a film. This is particularly feasible if photographic sound records are used. The latter may be placed on one margin only, or be distributed on both margins, as hereinafter described.

As the sound records are intended to be placed at the margins of the film, there is no interference of picture and sound record as would be the case, if for instance, the latter were placed across the reverse face of the film, as in such case, they would be projected upon the picture screen.

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It will be noted that there are no abrupt changes in the direction of moving parts. All parts move in a uniform manner, and the apparatus as a whole is very simple. It is to be especially noted that, although the recording speed is rather high, neither the film carrier nor the recorders move at this speed, the high speed mentioned being due to the relative motion of recorder and film. This means that considerable wear is saved in the apparatus.

One can readily see that by employing a suitable number of recorders moving at a proper speed, photographic sound recording processes requiring a speed of six feet per second may be utilized so that they may be placed on a film that is moving at the standard motion picture speed of one foot per second.

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Figure 6 is a view of the film used.

Figure 7 is a diagrammatic illustration of a sound reproducer installation in conjunction with a projection screen.

Figure 8 is a diagrammatic illustration of a recording apparatus as arranged for operation.

Figure 9 corresponds to Figure 1, but shows an additional means for maintaining the film in intimate contact with the wheel.

There are many ways of carrying out the invention, and although certain structures will be described in detail, the invention is not limited to them. The film A is passed around the large sprocket wheel 1, which serves as a film carrier contact roll 10 hold-

ing it in engagement with sprocket teeth 11, as shown in Figure 1. The film then passes over a smaller sprocket 13, to which is rigidly attached the gear wheel 5. It is obvious that sprocket 13 pulls the film forward. Wheel 5 communicates motion through wheel 4 to wheel 3, which is rigidly attached to shaft 14, which carries the radial arms 2, also rigidly attached to it, and bearing recording or reproducing means at their extremities. Toothed gear wheels 3, 4 and 5 are so proportioned that the devices at the extremities of the radial arms move, while in contact with the film surfaces, at a speed which is equal to (when two arms are employed) that of the film, but in the opposite direction. Obviously, the relative speeds of film and recorder passing over it, will be equal to the sum of their individual speeds. Consequently, if the speed of the film is one foot per second, the recording speed is twice this, or two feet per second. One can readily see that if the gearing is so arranged that the recorders move at a speed double that of the film, and three recorders are used, three records will be impressed, and the recording speed will be three feet per second. Four recorders with a speed of three feet per second would mean a recording speed of four feet per second, and so on.

It is obviously necessary to employ some means whereby only that recorder that is actually impressing its own specific record is in actual operation at any given time, all others being temporarily eliminated from activity. A very satisfactory method of accomplishing this is by the use of electricity, and this will now be described. Other methods will be described later. For this purpose, the commutator 6, Figure 2, is adjustably attached to the shaft, by means of set screws, or the like in such a position that brush 7 cuts out of circuit the recorder or recorders not functioning, and connecting only the recorder that is functioning. The commutator is shown in this case provided with two segments, 6*a* and 6*b* one being attached by wire 9 to the device at the extremity of one radial arm, and the other attached by wire 8 to the other recording device. The wire 9 passes through shaft 14 which may be provided with suitable conducting passages, 9*a*. In the drawing, the radial arms, shaft, etc., form part of the circuit, in which case only one brush 7 is necessary.

In Figures 1 and 2, the radial arms 2 are provided with simple electrical means for the purpose of electrically reproducing a provided with the stylus 18. The wire 8 and the metal body of the apparatus connects this device with the external reproducing circuit.

However, wires may be used throughout the circuit connections, and also more than one brush may be used in connection with the commutator. Besides the adjustment of the position of the commutator on the shaft, obviously the brush 7 may be attached to a movable support 7*a*, as is usual in electrical machinery, whereby it also may be moved to the most favorable position to obtain the best results.

The operation of the apparatus is perfectly simple. A device similar to that shown in Figure 1 may be attached to a camera or projector, and so connected that sprocket 13 is driven at standard motion picture feed, whereupon the recorder or reproducer will move in the opposite direction at the same speed (if but two recorders are used), with the result that the recording or reproducing speed is double that of the film, or about two feet per second.

The large sprocket wheel 1 is not fixed to the shaft 14, but is permitted to revolve freely upon it, and is held in position by the disks 12 and 12′, which are fixed firmly to the shaft, and which allow just sufficient play to let wheel 1 revolve freely without vibration. In the drawing, this wheel is shown as being operated by the film as it is drawn through the picture machine. However, a special gearing could be provided to move it directly, if desired.

Strong emphasis is placed on the recording or reproducing apparatus. This arrangement permits of electrical connections throughout, permitting the use of a commutator, as well as the actual reproduction of the sound record at a distance from the reproducer 54, Fig. 7, such as for instance at a projection screen 51. Moreover, the use of microphones 58 or the like in the camera 57 permits the use of special electrical apparatus 55, not otherwise available, whereby amplification of the sound record may be attained, the recorder being indicated at 56. Such amplifying means 53 are also available in the reproduction of the sound record by the reproducing apparatus indicated at 54. The alternate connecting and disconnecting of the recorders is also more effectively accomplished by the employment of an electrical commutator.

The set screw 16 rigidly fastens the disk 12 to shaft 14. Recorder 17 is detachable from the radial arm.

Figure 4 shows a photographic recorder

ducting metallic body of the arm. The radial arm may be detached from the disk of the corresponding socket. Any type of sound recorder may thus be attached to the radial arm. The term radial member may be construed to mean not only the mechanical device but also a device that is partly made up of a light beam, which is directed by proper apparatus toward the moving film to chemically alter it.

The photographic method of reproducing is used, and the selenium cell 25 or equivalent, is made in the form of strip arranged in a semicircle, corresponding to the form of the curved film. The effective part of the cell will be thus in the form of a long, narrow member over which the light recorder on the radial arm passes longitudinally. Consequently, as the light is not stationary, a heat-absorbing means will be unnecessary.

By making the rotating film carrier 1 of very large diameter, the styli would remain in contact with the film for a much longer period. Also the possibility of the commutation of the different reproducers being audibly detected by the audience would be minimized.

Each recorder contacts with the precise transverse portion of the film throughout the length of the film. As the latter is held rigidly in position, the proper sound reproducer finds its corresponding record with absolute precision.

By making shaft 14 sufficiently long and adding one of more extra arms similiar to 2 and 2' and spacing them equidistantly on the shaft, and changing the gearing to rotate them at the proper speed, which is a multiple of the film speed, the sound recording speed is thus increased. The electrical connections and commutator must be also adjusted to correspond. The flexibility of the mechanism is obvious.

In order to offer a firm support to the film while the recorder is passing over its surface, an endless belt 67 as shown in Fig. 9 made of a substance approximating the density of ordinary phonograph record backing material, such as waxed paper, may be arranged so as to pass around the contact roll 10 and sprocket 13. This belt may be provided with a slack adjuster consisting, for instance of a weighted pulley 71, 72 indicating the weight.

Wheels 3, 4 and 5 are supported on any suitable frame work 30. Power is preferably applied to 5 or 13, so as to move the film at standard motion picture speed. The film, however, may be simply pulled through the apparatus by other sprocket wheels.

Photographic sound recording has been very successful commercially and as there ords there and utilizing them to reproduce sounds. Moreover, by this means a recording speed is available that is in excess of that used in commercial sound recording.

An advantage of electrical commutation is that a record can come into contact with the film for a time before it is actually brought into electrical connection.

Having thus described my invention, I claim as new and desire to secure by Letters Patent,

1. A phonographic apparatus comprising a sound record consisting of a film strip having a sound track extending longitudinally thereof and a wheel directly supporting that portion of the film laterally adjacent to the portion of the sound record from which sound is reproduced, the sound record portion being otherwise unsupported thereby.

2. A phonographic apparatus comprising a sound record consisting of a film strip having a sound track extending longitudinally thereof and a narrow wheel directly supporting that portion of the film laterally adjacent to the portion of the sound record from which sound is reproduced, the sound record portion being otherwise unsupported thereby.

3. In combination, phonographic means and film supporting means adapted to carry a film type sound record in an arcuate path with the sound record portion of the film extending otherwise unsupported into cooperative relation to said first means.

4. In a phonographic apparatus for sound film records having a sound track extending longitudinally thereof, in combination, means for moving the film past an operational point at a uniform speed, and rotary means for supporting the film across a portion only of the width thereof at the said point and means for transfer of acoustic energy cooperating with a portion of the remaining width of the film.

5. In sound reproducing mechanism for film having a portion adapted to be supported and an optically varying sound record on a portion laterally of the surface therefrom, a photo-electric reproducer, rotary supporting means for moving the film and means for maintaining the film on the supporting means with the sound record portion extending otherwise unsupported in operative relation to said reproducer.

6. In combination, means including a wheel to carry a film having a sound record adjacent to the edge thereof with said sound record extending beyond the side of said wheel, and a light-sensitive cell and a light source so arranged as to cooperate with said portion of the film extending from the

ing it in engagement with sprocket teeth 11, as shown in Figure 1. The film then passes over a smaller sprocket 13, to which is rigidly attached the gear wheel 5. It is obvious that sprocket 13 pulls the film forward. Wheel 5 communicates motion through wheel 4 to wheel 3, which is rigidly attached to shaft 14, which carries the radial arms 2, also rigidly attached to it, and bearing recording or reproducing means at their extremities. Toothed gear wheels 3, 4 and 5 are so proportioned that the devices at the extremities of the radial arms move, while in contact with the film surfaces, at a speed which is equal to (when two arms are employed) that of the film, but in the opposite direction. Obviously, the relative speeds of film and recorder passing over it, will be equal to the sum of their individual speeds. Consequently, if the speed of the film is one foot per second, the recording speed is twice this, or two feet per second. One can readily see that if the gearing is so arranged that the recorders move at a speed double that of the film, and three recorders are used, three records will be impressed, and the recording speed will be three feet per second. Four recorders with a speed of three feet per second would mean a recording speed of four feet per second, and so on.

It is obviously necessary to employ some means whereby only that recorder that is actually impressing its own specific record is in actual operation at any given time, all others being temporarily eliminated from activity. A very satisfactory method of accomplishing this is by the use of electricity, and this will now be described. Other methods will be described later. For this purpose, the commutator 6, Figure 2, is adjustably attached to the shaft, by means of set screws, or the like in such a position that brush 7 cuts out of circuit the recorder or recorders not functioning, and connecting only the recorder that is functioning. The commutator is shown in this case provided with two segments, 6*a* and 6*b* one being attached by wire 9 to the device at the extremity of one radial arm, and the other attached by wire 8 to the other recording device. The wire 9 passes through shaft 14 which may be provided with suitable conducting passages, 9*a*. In the drawing, the radial arms, shaft, etc., form part of the circuit, in which case only one brush 7 is necessary.

In Figures 1 and 2, the radial arms 2 are provided with simple electrical means for the purpose of electrically reproducing a photographic sound record as hereinafter described. The two contact brushes are shown at 15. Figure 3, however, shows a radial arm provided with an electrically operated, mechanical sound reproducer 17, provided with the stylus 18. The wire 8 and the metal body of the apparatus connects this device with the external reproducing circuit.

However, wires may be used throughout the circuit connections, and also more than one brush may be used in connection with the commutator. Besides the adjustment of the position of the commutator on the shaft, obviously the brush 7 may be attached to a movable support 7*a*, as is usual in electrical machinery, whereby it also may be moved to the most favorable position to obtain the best results.

The operation of the apparatus is perfectly simple. A device similar to that shown in Figure 1 may be attached to a camera or projector, and so connected that sprocket 13 is driven at standard motion picture feed, whereupon the recorder or reproducer will move in the opposite direction at the same speed (if but two recorders are used), with the result that the recording or reproducing speed is double that of the film, or about two feet per second.

The large sprocket wheel 1 is not fixed to the shaft 14, but is permitted to revolve freely upon it, and is held in position by the disks 12 and 12′, which are fixed firmly to the shaft, and which allow just sufficient play to let wheel 1 revolve freely without vibration. In the drawing, this wheel is shown as being operated by the film as it is drawn through the picture machine. However, a special gearing could be provided to move it directly, if desired.

Strong emphasis is placed on the recording or reproducing apparatus. This arrangement permits of electrical connections throughout, permitting the use of a commutator, as well as the actual reproduction of the sound record at a distance from the reproducer 54, Fig. 7, such as for instance at a projection screen 51. Moreover, the use of microphones 58 or the like in the camera 57 permits the use of special electrical apparatus 55, not otherwise available, whereby amplification of the sound record may be attained, the recorder being indicated at 56. Such amplifying means 53 are also available in the reproduction of the sound record by the reproducing apparatus indicated at 54. The alternate connecting and disconnecting of the recorders is also more effectively accomplished by the employment of an electrical commutator.

The set screw 16 rigidly fastens the disk 12 to shaft 14. Recorder 17 is detachable from the radial arm.

Figure 4 shows a photographic recorder 21, consisting of a small tungsten incandescent tubular lamp attached to the extremity of the radial member. It is firmly held in position by the screw 19, while electrical connection is made by the wire 8 and con-

ducting metallic body of the arm. The radial arm may be detached from the disk of the corresponding socket. Any type of sound recorder may thus be attached to the radial arm. The term radial member may be construed to mean not only the mechanical device but also a device that is partly made up of a light beam, which is directed by proper apparatus toward the moving film to chemically alter it.

The photographic method of reproducing is used, and the selenium cell 25 or equivalent, is made in the form of strip arranged in a semicircle, corresponding to the form of the curved film. The effective part of the cell will be thus in the form of a long, narrow member over which the light recorder on the radial arm passes longitudinally. Consequently, as the light is not stationary, a heat-absorbing means will be unnecessary.

By making the rotating film carrier 1 of very large diameter, the styli would remain in contact with the film for a much longer period. Also the possibility of the commutation of the different reproducers being audibly detected by the audience would be minimized.

Each recorder contacts with the precise transverse portion of the film throughout the length of the film. As the latter is held rigidly in position, the proper sound reproducer finds its corresponding record with absolute precision.

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In order to offer a firm support to the film while the recorder is passing over its surface, an endless belt 67 as shown in Fig. 9 made of a substance approximating the density of ordinary phonograph record backing material, such as waxed paper, may be arranged so as to pass around the contact roll 10 and sprocket 13. This belt may be provided with a slack adjuster consisting, for instance of a weighted pulley 71, 72 indicating the weight.

Wheels 3, 4 and 5 are supported on any suitable frame work 30. Power is preferably applied to 5 or 13, so as to move the film at standard motion picture speed. The film, however, may be simply pulled through the apparatus by other sprocket wheels.

Photographic sound recording has been very successful commercially, and as there is room for many such records on the margin of a moving picture film, the invention offers a means of placing several such records there and utilizing them to reproduce sounds. Moreover, by this means a recording speed is available that is in excess of that used in commercial sound recording.

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2. A phonographic apparatus comprising a sound record consisting of a film strip having a sound track extending longitudinally thereof and a narrow wheel directly supporting that portion of the film laterally adjacent to the portion of the sound record from which sound is reproduced, the sound record portion being otherwise unsupported thereby.

3. In combination, phonographic means and film supporting means adapted to carry a film type sound record in an arcuate path with the sound record portion of the film extending otherwise unsupported into cooperative relation to said first means.

4. In a phonographic apparatus for sound film records having a sound track extending longitudinally thereof, in combination, means for moving the film past an operational point at a uniform speed, and rotary means for supporting the film across a portion only of the width thereof at the said point and means for transfer of acoustic energy cooperating with a portion of the remaining width of the film.

5. In sound reproducing mechanism for film having a portion adapted to be supported and an optically varying sound record on a portion laterally of the surface therefrom, a photo-electric reproducer, rotary supporting means for moving the film and means for maintaining the film on the supporting means with the sound record portion extending otherwise unsupported in operative relation to said reproducer.

6. In combination, means including a wheel to carry a film having a sound record adjacent to the edge thereof with said sound record extending beyond the side of said wheel, and a light-sensitive cell and a light source so arranged as to cooperate with said portion of the film extending from the wheel for the reproduction of the sound record therefrom.

7. In combination, means including a nar-

row wheel to carry a film having a sound record adjacent to the edge thereof with said sound record extending beyond the side of said wheel, and a light-sensitive cell and a light source so arranged as to cooperate with said portion of the film extending from the wheel for the reproduction of the sound record therefrom.

8. In combination, means including a wheel to carry a film having a sound record adjacent to the edge thereof with said sound record extending beyond the side of said wheel, an elongated photo-cell and a light source so arranged as to cooperate with said portion of the film extending from the wheel for the reproduction of the sound record therefrom.

9. In combination, means including a wheel to carry a film having a sound record adjacent to the edge thereof with said sound record extending beyond the side of said wheel, and a photo-electric cell and a light source arranged in cooperative relation with respectively opposite sides of said portion of the film extending beyond the side of said wheel.

10. In combination, a light-sensitive cell, a light source, and means including a rotary film supporting means to carry a film strip type sound record in an arcuate path between the two first-named means, the sound record portion of said film extending otherwise unsupported between said two first-named means.

11. In phonographic apparatus in which the sound record is photographically recorded on a film, the combination of a wheel means for rotating said wheel at uniform speed, means for feeding a record film on to said wheel at one point and off therefrom at another point and causing the film to adhere closely to the wheel without slippage between said points, said film record being arranged to overhang one side of the wheel, a photo cell positioned in cooperative relation to the overhanging position of the film and means for directing light through said overhanging portion of the film onto said photo cell.

12. In sound reproducing mechanism for film having an optically varying sound record extending longitudinally on the surface thereof, a photo-electric reproducer, rotary supporting means for moving the film and means for maintaining the film on the supporting means with the sound record portion extending otherwise unsupported beyond the edge thereof and into cooperative relation with said reproducer.

13. In a sound reproducer for film having a photographic sound record extending longitudinally on the surface thereof, revolving means for moving the film, a photo-electric cell so located as to be affected by light passing through the film and means for revolving the first named means and moving said film.

14. In sound reproducing mechanism for a film strip having a photographic sound record extending longitudinally thereon, in combination, a photo-cell, means for moving the film past the photo-cell at a uniform speed, a light source, means for moving the light source longitudinally of the film, and means for so supporting the film adjacent to the photo-cell that light from said light source may have unobstructed passage therethrough to the said cell.

15. In sound reproducing mechanism for a film strip having a photographic sound record extending longitudinally thereon, in combination, a longitudinally elongated photo-cell, means for moving the film longitudinally past the photo-cell at a uniform speed, a light source, means for moving the light source longitudinally of the film and photo-cell, and means for so supporting the film adjacent to the photo-electric cell that light from said light source may have unobstructed passage therethrough to the said cell.

16. In a sound reproducer for film having a sound record adjacent the edge thereof, in combination, a wheel to support the film adjacent to a reproduction point, means for maintaining the film on the wheel with the sound record over-hanging the edge thereof and sound reproducing means to cooperate with the sound record on the overhanging edge of said film.

17. In a sound reproducer for film having a sound record adjacent the edge thereof, in combination, a wheel to support the film adjacent to a reproduction point, means for maintaining the film on the wheel with the sound record over-hanging the edge thereof and sound reproducing means to cooperate with the sound record on the over-hanging edge of said film.

18. In a sound reproducer for film having a sound record adjacent the edge thereof, in combination, a wheel to support the film adjacent to a reproduction point, and means for maintaining the film on the wheel with the sound record overhanging the edge thereof.

19. In a sound reproducer for film having a sound record adjacent the edge thereof, in combination, a narrow wheel to support the film adjacent to a reproduction point, and means for maintaining the film on the wheel with the sound record overhanging the edge thereof.

20. In a sound reproducer for film having a sound record adjacent the edge there-

wheel with the sound record over-hanging the edge thereof.

21. In sound reproducing mechanism for film having an optically varying sound record on the surface thereof, a photo-electric sound reproducer; rotary supporting means adjacent said reproducer for carrying the film past said sound reproducer, and means comprising a yieldable pulley for maintaining said film against said supporting means.

22. In a sound reproducer for film having a sound record adjacent the edge thereof, in combination, a wheel adapted to support the film at a reproduction point, yieldable means for maintaining the film on the wheel with the sound record overhanging the edge thereof, and sound reproducing means adapted to cooperate with the sound record on the overhanging edge of said film.

23. In apparatus of the class described, a wheel adapted to support a motion picture film having a sound record adjacent to the edge thereof with means whereby the sound record portion of the film extends beyond the edge of the wheel, said wheel being relatively large, and means for moving said film through said apparatus.

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row wheel to carry a film having a sound record adjacent to the edge thereof with said sound record extending beyond the side of said wheel, and a light-sensitive cell and a light source so arranged as to cooperate with said portion of the film extending from the wheel for the reproduction of the sound record therefrom.

8. In combination, means including a wheel to carry a film having a sound record adjacent to the edge thereof with said sound record extending beyond the side of said wheel, an elongated photo-cell and a light source so arranged as to cooperate with said portion of the film extending from the wheel for the reproduction of the sound record therefrom.

9. In combination, means including a wheel to carry a film having a sound record adjacent to the edge thereof with said sound record extending beyond the side of said wheel, and a photo-electric cell and a light source arranged in cooperative relation with respectively opposite sides of said portion of the film extending beyond the side of said wheel.

10. In combination, a light-sensitive cell, a light source, and means including a rotary film supporting means to carry a film strip type sound record in an arcuate path between the two first-named means, the sound record portion of said film extending otherwise unsupported between said two first-named means.

11. In phonographic apparatus in which the sound record is photographically recorded on a film, the combination of a wheel means for rotating said wheel at uniform speed, means for feeding a record film on to said wheel at one point and off therefrom at another point and causing the film to adhere closely to the wheel without slippage between said points, said film record being arranged to overhang one side of the wheel, a photo cell positioned in cooperative relation to the overhanging position of the film and means for directing light through said overhanging portion of the film onto said photo cell.

12. In sound reproducing mechanism for film having an optically varying sound record extending longitudinally on the surface thereof, a photo-electric reproducer, rotary supporting means for moving the film and means for maintaining the film on the supporting means with the sound record portion extending otherwise unsupported beyond the edge thereof and into cooperative relation with said reproducer.

13. In a sound reproducer for film having a photographic sound record extending longitudinally on the surface thereof, revoluble means for directing light on the film, a rotary means maintaining the film in the path of revolution of said light, a photo-electric cell so located as to be affected by light passing through the film and means for revolving the first named means and moving said film.

14. In sound reproducing mechanism for a film strip having a photographic sound record extending longitudinally thereon, in combination, a photo-cell, means for moving the film past the photo-cell at a uniform speed, a light source, means for moving the light source longitudinally of the film, and means for so supporting the film adjacent to the photo-cell that light from said light source may have unobstructed passage therethrough to the said cell.

15. In sound reproducing mechanism for a film strip having a photographic sound record extending longitudinally thereon, in combination, a longitudinally elongated photo-cell, means for moving the film longitudinally past the photo-cell at a uniform speed, a light source, means for moving the light source longitudinally of the film and photo-cell, and means for so supporting the film adjacent to the photo-electric cell that light from said light source may have unobstructed passage therethrough to the said cell.

16. In a sound reproducer for film having a sound record adjacent the edge thereof, in combination, a wheel to support the film adjacent to a reproduction point, means for maintaining the film on the wheel with the sound record over-hanging the edge thereof and sound reproducing means to cooperate with the sound record on the overhanging edge of said film.

17. In a sound reproducer for film having a sound record adjacent the edge thereof, in combination, a wheel to support the film adjacent to a reproduction point, means for maintaining the film on the wheel with the sound record over-hanging the edge thereof and sound reproducing means to cooperate with the sound record on the over-hanging edge of said film.

18. In a sound reproducer for film having a sound record adjacent the edge thereof, in combination, a wheel to support the film adjacent to a reproduction point, and means for maintaining the film on the wheel with the sound record overhanging the edge thereof.

19. In a sound reproducer for film having a sound record adjacent the edge thereof, in combination, a narrow wheel to support the film adjacent to a reproduction point, and means for maintaining the film on the wheel with the sound record overhanging the edge thereof.

20. In a sound reproducer for film having a sound record adjacent the edge thereof, in combination, a large wheel to support the film adjacent to a reproduction point, and means for maintaining the film on the

wheel with the sound record over-hanging the edge thereof.

21. In sound reproducing mechanism for film having an optically varying sound record on the surface thereof, a photo-electric sound reproducer; rotary supporting means adjacent said reproducer for carrying the film past said sound reproducer, and means comprising a yieldable pulley for maintaining said film against said supporting means.

22. In a sound reproducer for film having a sound record adjacent the edge thereof, in combination, a wheel adapted to support the film at a reproduction point, yieldable means for maintaining the film on the wheel with the sound record overhanging the edge thereof, and sound reproducing means adapted to cooperate with the sound record on the overhanging edge of said film.

23. In apparatus of the class described, a wheel adapted to support a motion picture film having a sound record adjacent to the edge thereof with means whereby the sound record portion of the film extends beyond the edge of the wheel, said wheel being relatively large, and means for moving said film through said apparatus.

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SOUND RECORDING OR REPRODUCING APPARATUS

Original Filed Jan. 8, 1921 3 Sheets-Sheet 1

Fig. 1

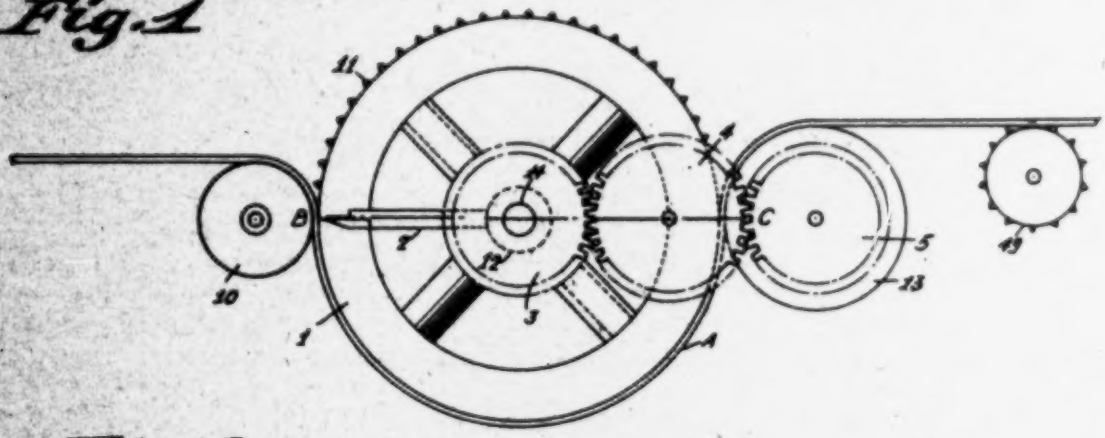


Fig. 2

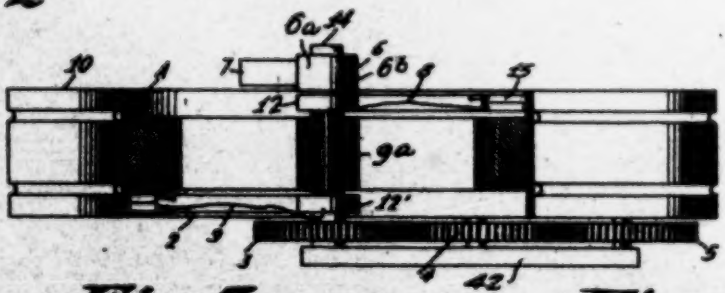


Fig. 3

Fig. 4

Fig. 5

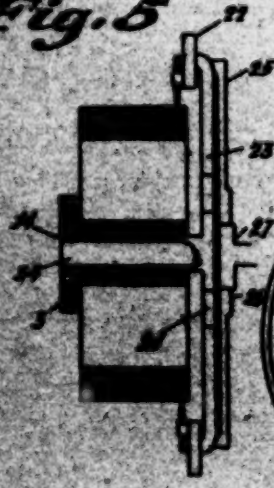


Fig. 6

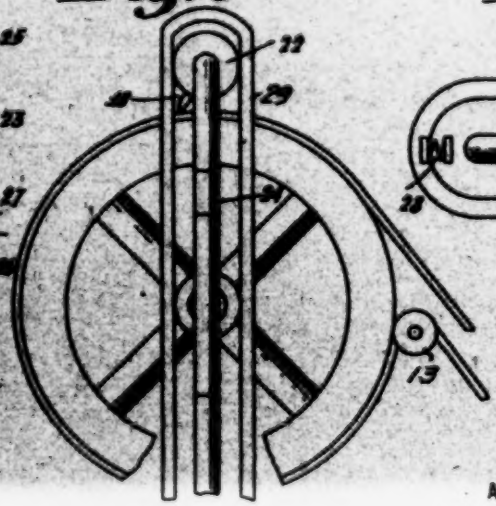
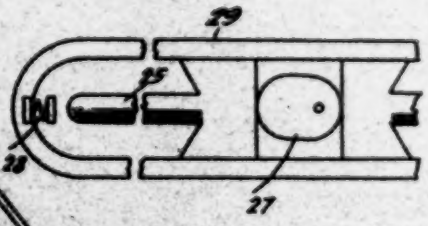


Fig. 7



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SOUND RECORDING OR REPRODUCING APPARATUS

Original Filed Jan. 8, 1921 3 Sheets-Sheet 1

Fig. 1

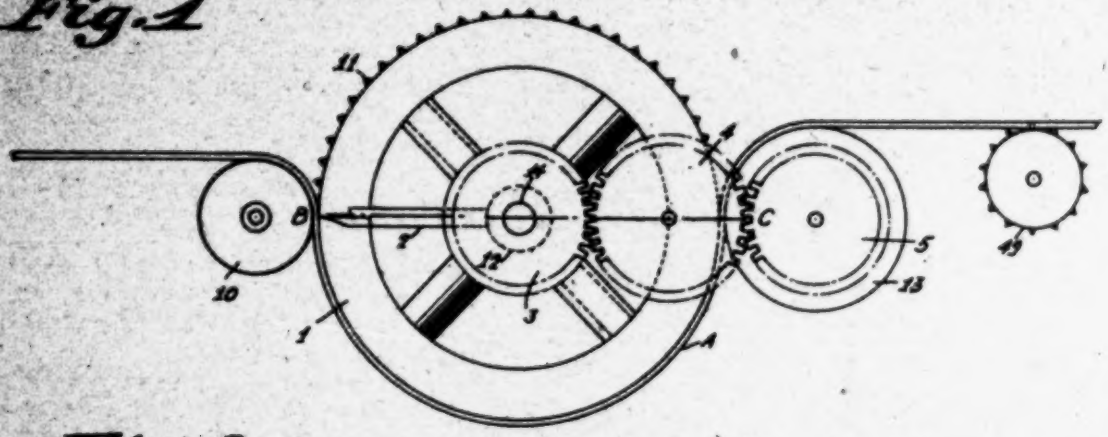


Fig. 2

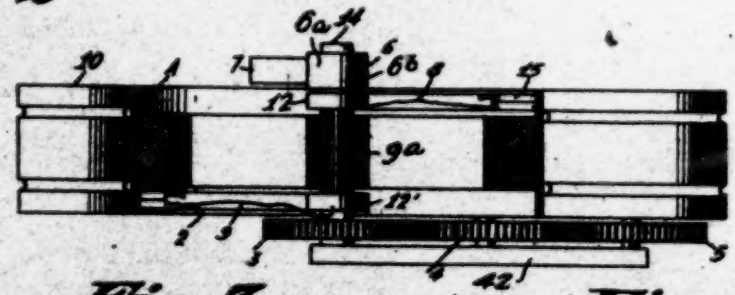


Fig. 3

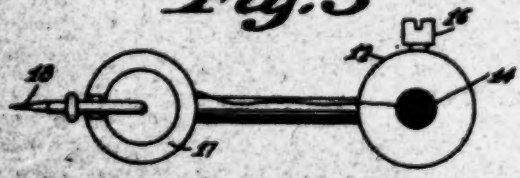


Fig. 4

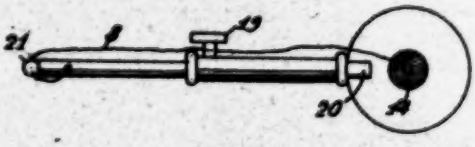


Fig. 5

Fig. 6

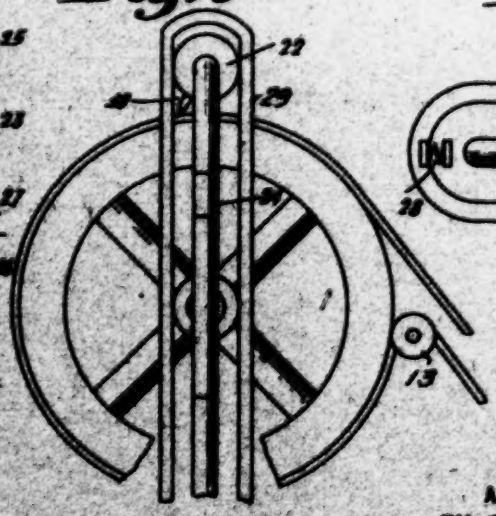
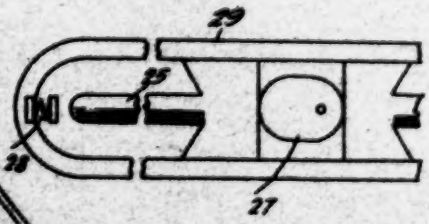


Fig. 7



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SOUND RECORDING OR REPRODUCING APPARATUS

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Fig. 13

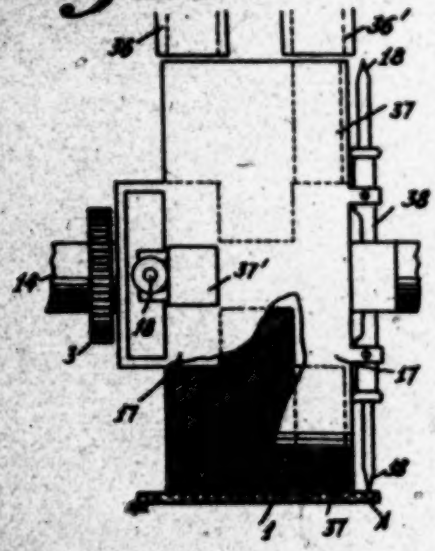

Fig. 14

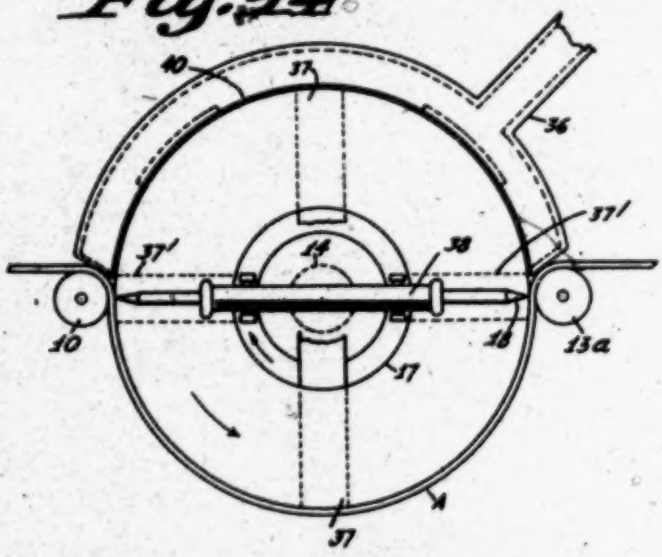

Fig. 8

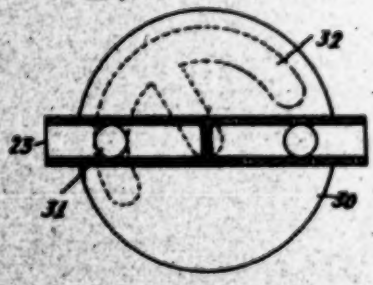

Fig. 9

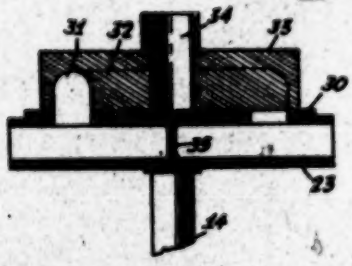

Fig. 10a

Fig. 10b

Fig. 11

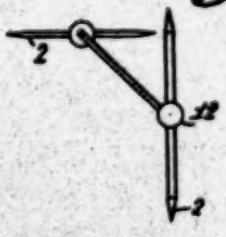

Fig 12

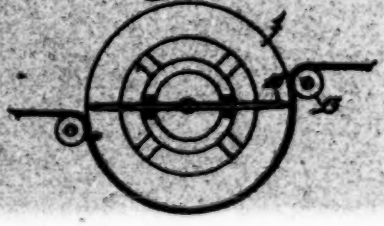

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Fig. 13

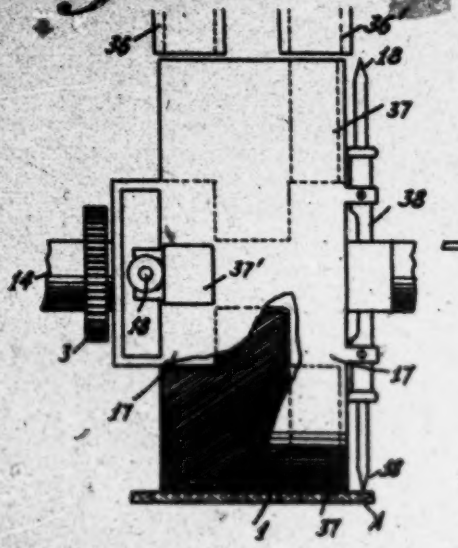

Fig. 14

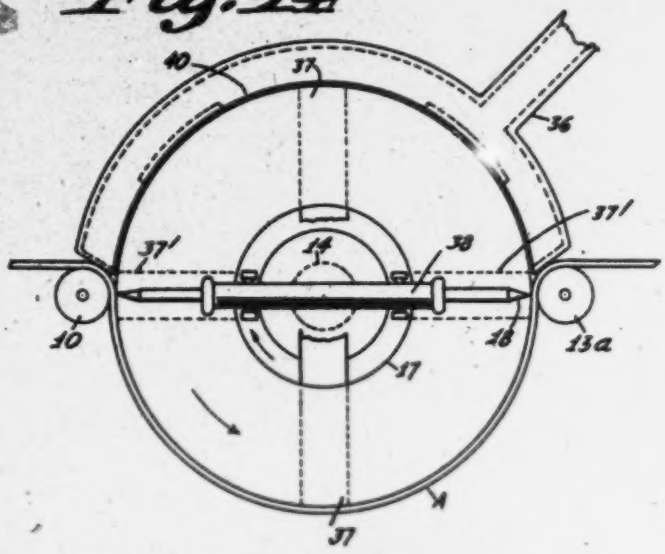

Fig. 8

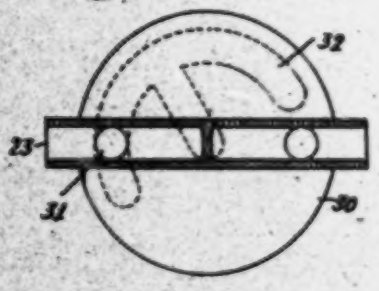

Fig. 9

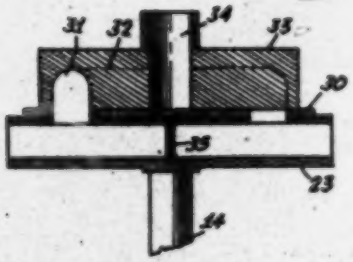

Fig. 10a

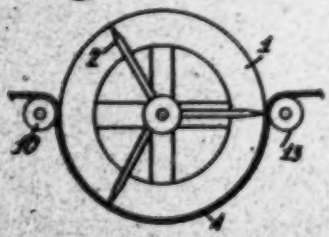

Fig. 10b

Fig. 11

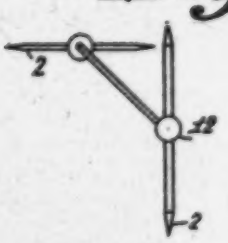

Fig 12

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SOUND RECORDING OR REPRODUCING APPARATUS

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Fig. 15

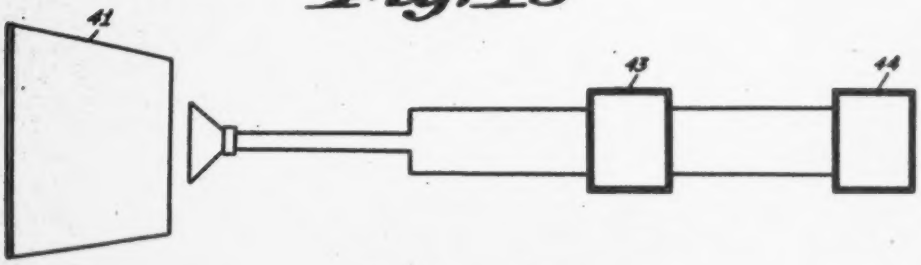


Fig. 16

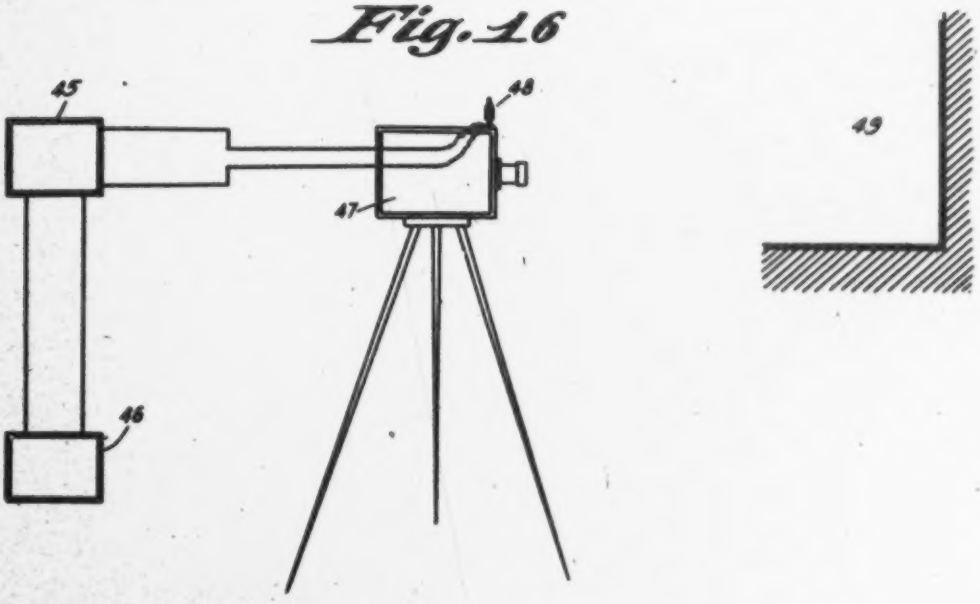
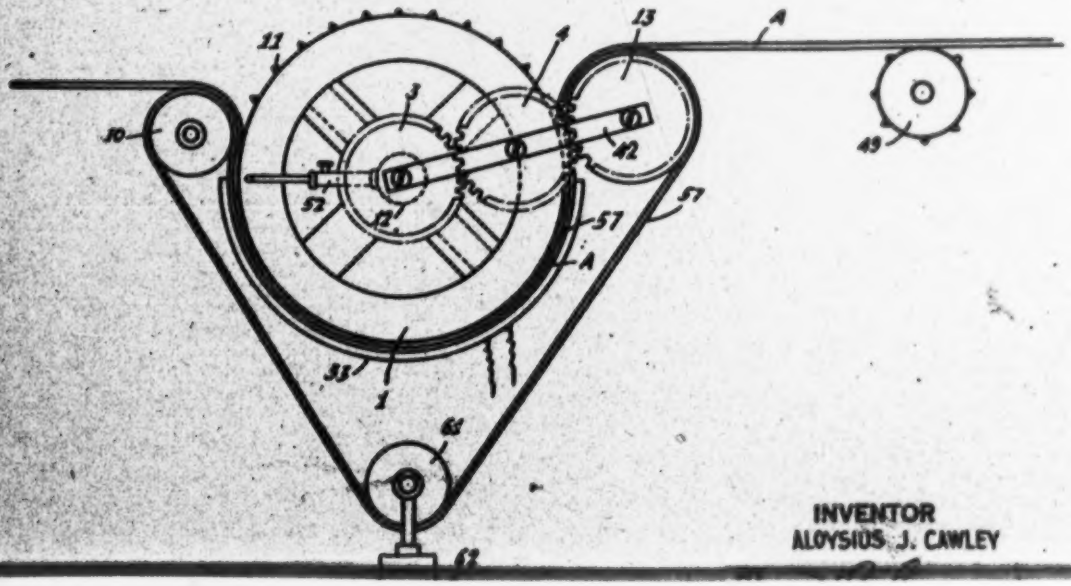


Fig. 17



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Patented Sept. 29, 1931

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UNITED STATES PATENT OFFICE

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SOUND RECORDING OR REPRODUCING APPARATUS

Original application filed January 8, 1921, Serial No. 435,984. Divided and this application filed September 18, 1929. Serial No. 393,072.

Claim 1 filed 12/12

This application is a division of my application Serial No. 435,984 filed January 8, 1921.

The invention relates generally to the method of producing sound records on motion picture films, so that sound and picture records may be synchronously reproduced, although the invention is not necessarily limited to this field.

More particularly, the invention is concerned with the recording of sound on a motion picture film at a recording speed that is much in excess of the speed of the film. An arrangement is provided whereby a recorder contacts with a film, while moving in the opposite direction thereto. The recording speed is thus equal to the sum of the speeds of the recorder and film.

A plurality of recorders are employed, which contact alternately with separate portions of the film. These recorders are placed radially at fixed intervals, and one contacts with a record surface of a given length, while the film has actually passed through but a fraction of this length. The other recorder is then in a position to contact with an equivalent length juxtaposed to, or opposite to that traversed by the first.

An electrical or mechanical arrangement is provided whereby the recorders are thrown out of operation when not recording their own specific record groove.

Arrangements are described whereby any desired sound recording speed may be obtained without any increase in the speed of the film, by simply increasing the number and speed of the recording units.

The invention is perfectly adaptable to the standard motion picture film as it exists in practice at present, and is concerned with placing sound records on the margin, or margins of such a film. This is particularly feasible if mechanical sound grooves are used, as there is room for a very large number as would be the case, if for instance, the latter were placed across the reverse face of the film, as in such case, they would be projected upon the picture screen.

The invention, further, is not limited to mere mechanical methods of recording, but is adapted to any means, such as photographic, magnetic, or the electrical reproduction described in another application that I am about to file. Although the invention is not limited to any of those methods, great emphasis is placed on the method employing electrically operated sound recorders and reproducers; the recording speed that it is most desired to use with this is approximately double the film speed.

It will be noted that there are no abrupt changes in the direction of moving parts. All parts move in a uniform manner, and the apparatus as a whole is very simple. It is to be especially noted that, although the recording speed is rather high, neither the film carrier nor the recorders move at this speed, the high speed mentioned being due to the relative motion of recorder and film. This means that considerable wear is saved in the apparatus.

One can readily see that by employing a suitable number of recorders moving at a proper speed, that photographic sound recording processes requiring a speed of six feet per second may be utilized so that they may be placed on a film that is moving at the standard motion picture speed of one foot per second.

For a more complete understanding of the invention, reference is to be had to the following description and claims taken in connection with the accompanying drawings, in which like characters of reference denote corresponding parts in all the views, and in which,

Figure 1 is an elevational view showing an electrical reproducing device.

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Fig. 15

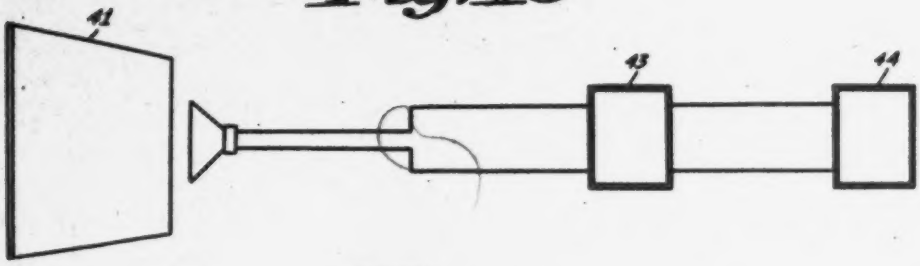


Fig. 16

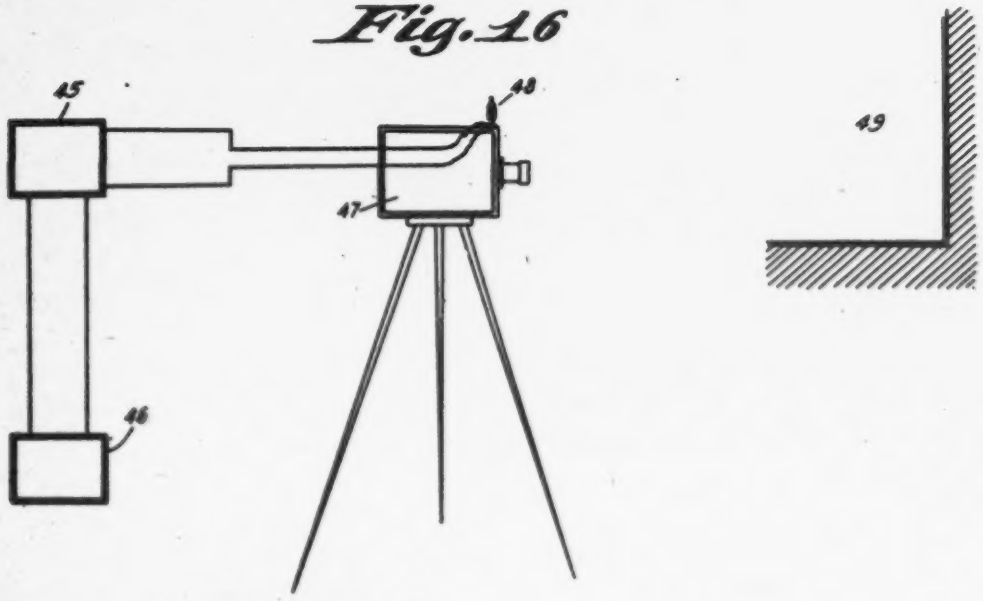
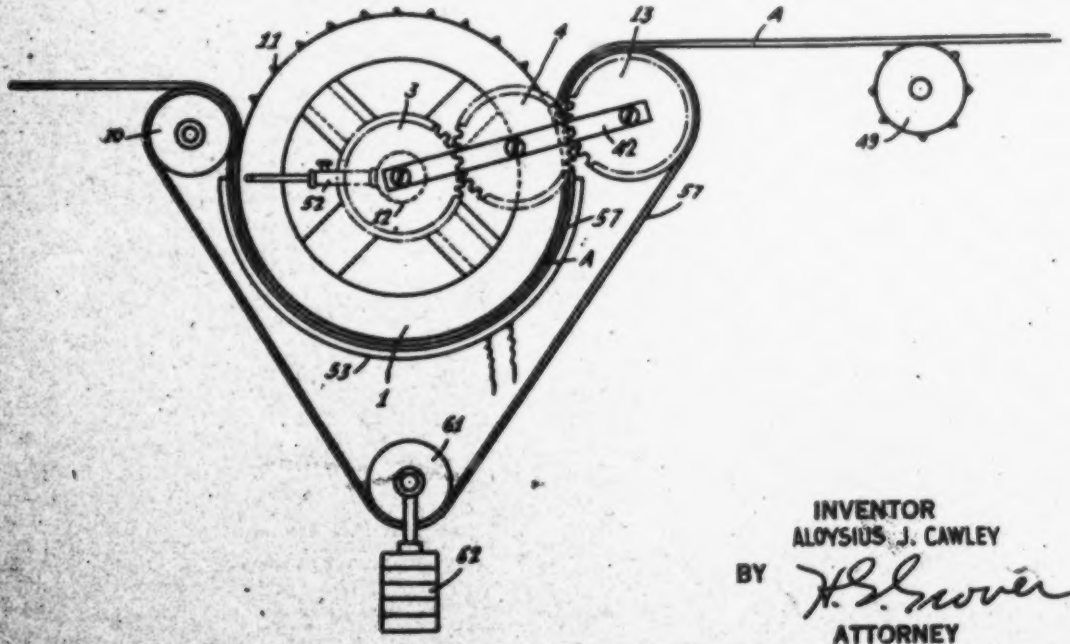


Fig. 17



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SOUND RECORDING OR REPRODUCING APPARATUS

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A plurality of recorders are employed, which contact alternately with separate portions of the film. These recorders are placed radially at fixed intervals, and one contacts with a record surface of a given length, while the film has actually passed through but a fraction of this length. The other recorder is then in a position to contact with an equivalent length juxtaposed to, or opposite to that traversed by the first.

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Arrangements are described whereby any desired sound recording speed may be obtained without any increase in the speed of the film, by simply increasing the number and speed of the recording units.

The invention is perfectly adaptable to the standard motion picture film as it exists in practice at present, and is concerned with placing sound records on the margin, or margins of such a film. This is particularly feasible if mechanical sound grooves are used, as there is room for a very large number of such records. The latter may be placed on one margin only, or be distributed on both margins, as hereinafter described.

As the sound records are intended to be placed on the margins of the film, there is no interference of picture and sound record as would be the case, if for instance, the latter were placed across the reverse face of the film, as in such case, they would be projected upon the picture screen.

The invention, further, is not limited to mere mechanical methods of recording, but is adapted to any means, such as photographic, magnetic, or the electrical reproduction described in another application that I am about to file. Although the invention is not limited to any of those methods, great emphasis is placed on the method employing electrically operated sound recorders and reproducers; the recording speed that it is most desired to use with this is approximately double the film speed.

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One can readily see that by employing a suitable number of recorders moving at a proper speed, that photographic sound recording processes requiring a speed of six feet per second may be utilized so that they may be placed on a film that is moving at the standard motion picture speed of one foot per second.

For a more complete understanding of the invention, reference is to be had to the following description and claims taken in connection with the accompanying drawings, in which like characters of reference denote corresponding parts in all the views, and in which,

Figure 1 is an elevational view showing an electrical reproducing device.

Figure 2 is a cross sectional view on line BC of the rotating film carrier.

Figure 3 is an elevational view of an electrically operated, mechanical sound recorder placed on a radial arm.

Figure 4 is a plan view of a photographic

sound recorder placed on a radial arm, also illustrating the detachable nature of the latter.

Figure 5 is a plan view of a device employing mechanical recording, whereby the non-functioning recorder is raised from the film surface at the proper time.

Figure 6 is a side view of a mechanical recording arrangement.

Figure 7 is a view showing the radial arms, stationary cam and contacts for raising recorder from film surface.

Figure 8 is a plan view of the disk attached to the hollow tubes, showing the passage in the valve body above.

Figure 9 is a cross sectional view of the valve body, showing the communicating passages made with the tubes below.

Figure 10, *a* and *b*, are diagrammatic views showing the arrangements of two and three recorders, respectively.

Figure 11 is a diagrammatic view showing two recorders adapted to play on each margin of the film.

Figure 12 is an elevational view showing the recorder diaphragm placed at the center of the revolving element, with styli extending as radial arms.

Figures 13 and 14 show another type of valve arrangement.

Figure 15 is a diagrammatic illustration of a reproducing apparatus provided with an amplifier and in cooperative relation to a projector screen.

Figure 16 is a diagrammatic illustration of the arrangement of apparatus for recording.

Figure 17 corresponds to Figure 1 but includes the photo-electric reproducer of Figure 4 and additional means for supporting the film.

There are many ways of carrying out the invention, and although certain structures will be described in detail, the invention is not limited to them. The film A is passed around the large sprocket wheel 1, contact roll 10 holding it in engagement with sprocket teeth 11, as shown in Figure 1. The film then passes over a smaller sprocket 13, to which is rigidly attached the gear wheel 6. It is obvious that sprocket 13 may pull the film forward. Wheel 5 communicates motion through wheel 4 to wheel 3, which is rigidly attached to shaft 14, which carries the radial arms 2, also rigidly attached to it, and bearing recording or reproducing means at their extremities. Toothed gear wheels 3, 4 and 5 are so proportioned that the devices at the extremities of the radial arms move, while in contact with the film surfaces, at a speed which is equal to (when individual speeds. Consequently, if the speed of the film is one foot per second, the recording speed is twice this, or two feet per second. One can readily see that if the gearing is so arranged that the recorders move at a speed double that of the film, and three recorders are used, three records will be impressed, and the recording speed will be three feet per second. Four recorders with a speed of three feet per second would mean a recording speed of four feet per second, and so on.

It is obviously necessary to employ some means whereby only that recorder that is actually impressing its own specific record is in actual operation at any given time, all others being temporarily eliminated from activity. A very satisfactory method of accomplishing this is by the use of electricity, and this will now be described. Other methods will be described later. For this purpose, the commutator 6, Figure 2, is adjustably attached to the shaft, by means of set screws, or the like in such a position that brush 7 cuts out of circuit the recorder or recorders not functioning, and connecting only the recorder that is functioning. The commutator is shown in this case provided with two segments, 6*a* and 6*b* one being attached by wire 9 to the device at the extremity of one radial arm, and the other attached by wire 8 to the other recording device. The wire 9 passes through shaft 14 which may be provided with suitable conducting passages, 9*a*. In the drawing, the radial arms, shaft, etc., form part of the circuit, in which case only one brush 7 is necessary.

In Figures 1 and 2, the radial arms 2 are provided with simple electrical contacting brushes, for the purpose of electrically reproducing a photographic sound record described in my Patent Number 1,698,536. The two contact brushes are shown at 15. Figure 3, however, shows a radial arm provided with an electrically operated, mechanical sound reproducer 17, provided with the stylus 18. The wire 8 and the metal body of the apparatus connects this device with the external reproducing circuit.

However, wires may be used throughout for the circuit connections, and also more than one brush may be used in connection with the commutator. Besides the adjustment of the position of the commutator on the shaft, obviously the brush 7 may be attached to a movable support, as is usual in electrical machinery, whereby it also may be moved to the most favorable position to obtain the best results.

The operation of the apparatus is perfectly simple. A device similar to that

producer will move in the opposite direction at the same speed (if but two recorders are used), with the result that the recording or reproducing speed is double that of the film, or about two feet per second.

The large sprocket wheel 1 is not fixed to the shaft 14, but is permitted to revolve freely upon it, and is held in position by the disks 12 and 12', which are fixed firmly to the shaft, and which allow just sufficient play to let wheel 1 revolve freely without vibration. In the drawings, this wheel is shown as being operated by the film as it is drawn through the picture machine. However, a special gearing could be provided to move it directly, if desired.

Strong emphasis is placed on the recording or reproducing apparatus, of which Figure 3 is an illustration of the reproducer. This consists of a stylus operated by a telephone receiver to produce the sound record, and a stylus operating a microphone to reproduce it. This arrangement permits of electrical connections throughout, permitting the use of a commutator, as well as the actual reproduction of the sound record at a distance from the reproducer 44, Fig. 15, such as for instance at a projection screen 41. Moreover, the use of microphones 48 or the like in the camera 47 permits the use of special electrical apparatus 45, not otherwise available, whereby amplification of the sound record may be attained. Such amplifying means 43 are also available in the reproduction of the sound record by the reproducing apparatus indicated at 44, Fig. 15. The alternate connecting and disconnecting of the recorders is also more effectively accomplished by the employment of an electrical commutator. The set screw 16 rigidly fastens the disk 12 to shaft 14. Recorder 17 is detachable from the radial arm.

Figure 4 shows a photographic recorder 21, consisting of a small tungsten incandescent tubular lamp attached to the extremity of the radial member. It is firmly held in position by the screw 19, while electrical connection is made by the wire 8 and conducting metallic body of the arm. The radial arm may be detached from the disk by unscrewing the threaded end 20 out of the corresponding socket. Any type of sound recorder may thus be attached to the radial arm. The term radial member may be construed to mean not only the mechanical device but also a device that is partly made up of a light beam, which is directed by proper apparatus toward the moving film to chemically alter it. One readily sees that the invention is not concerned with any

without the use of electricity, recourse may be had to the device illustrated in Figures 5, 6 and 7. Here the film is wound upon the revolving film carrier as before. The shaft 14 is made hollow. The recorders 22 connect with the hollow shaft by means of the hollow radial members 23, having the flexible element 24, which may be either a section of rubber tubing or the like, or a sliding joint; this is designed to permit of the recorders 22 being lifted in turn from the surface of the film, by operation of the connections 25 provided with the shoes 26, which coact with the stationary cam 27. The cam is stationary, while the arms revolve. Gear wheel 3 is attached to the shaft 14, which is provided with the passage 34. External connection is made by means of a swivel or other flexible joint, which permits turning but is sufficiently sound tight. The action of spring 28 holds the shoes 26 in firm contact with the cam 27. Wheel 13 moves the film and toothed gear wheel 3, 4 and 5 move the radial members in the opposite direction as in Figure 1. It is to be understood that actual contact with the film is only made through part of the circumference of film carrier 1, namely the lower part shown in Figure 6. The radial member lifts the recorder completely away from the film surface when it reaches the upper part of the circumference, as shown in Figure 6; no trouble is occasioned by the ravelling and unravelling of the film at the point where they leave or arrive at the rotating member. The exact contour of the cam shown is not implied in the drawings, as it may be made in many forms other than that shown at 27, Figure 7.

Another modification, whereby the film is in contact with both recorders or reproducers at all times, commutation being made by means of a valve arrangement, is shown in Figures 8 and 9. A disk 30 is rigidly attached to the radial arms 23, and communicates therewith by means of the openings 31. Above this disk is placed the stationary valve body 33 having the passage 32 located directly over the disk 30. Passage 32 communicates with sound tube 34. Tubes 23 are isolated from each other by diaphragm, or partition 35. Moreover, those tubes are rigidly attached to shaft 14 as above described. It can be readily seen that as the radial tubes revolve together with disk 30, openings 31 communicate alternately with passage 32, so that at any given time, but one sound device is recording or reproducing. In other words, only the functioning recorder is in action.

illustrating the detachable nature of the latter.

Figure 5 is a plan view of a device employing mechanical recording, whereby the non-functioning recorder is raised from the film surface at the proper time.

Figure 6 is a side view of a mechanical recording arrangement.

Figure 7 is a view showing the radial arms, stationary cam and contacts for raising recorder from film surface.

Figure 8 is a plan view of the disk attached to the hollow tubes, showing the passage in the valve body above.

Figure 9 is a cross sectional view of the valve body, showing the communicating passages made with the tubes below.

Figure 10, *a* and *b*, are diagrammatic views showing the arrangements of two and three recorders, respectively.

Figure 11 is a diagrammatic view showing two recorders adapted to play on each margin of the film.

Figure 12 is an elevational view showing the recorder diaphragm placed at the center of the revolving element, with styli extending as radial arms.

Figures 13 and 14 show another type of valve arrangement.

Figure 15 is a diagrammatic illustration of a reproducing apparatus provided with an amplifier and in cooperative relation to a projector screen.

Figure 16 is a diagrammatic illustration of the arrangement of apparatus for recording.

Figure 17 corresponds to Figure 1 but includes the photo-electric reproducer of Figure 4 and additional means for supporting the film.

There are many ways of carrying out the invention, and although certain structures will be described in detail, the invention is not limited to them. The film A is passed around the large sprocket wheel 1, contact roll 10 holding it in engagement with sprocket teeth 11, as shown in Figure 1. The film then passes over a smaller sprocket 13, to which is rigidly attached the gear wheel 5. It is obvious that sprocket 13 may pull the film forward. Wheel 5 communicates motion through wheel 4 to wheel 3, which is rigidly attached to shaft 14, which carries the radial arms 2, also rigidly attached to it, and bearing recording or reproducing means at their extremities. Toothed gear wheels 3, 4 and 5 are so proportioned that the devices at the extremities of the radial arms move, while in contact with the film surfaces, at a speed which is equal to (when two arms are employed) that of the film, but in the opposite direction. Obviously, the relative speeds of film and recorder passing over it, will be equal to the sum of their speed of the film is one foot per second, the recording speed is twice this, or two feet per second. One can readily see that if the gearing is so arranged that the recorders move at a speed double that of the film, and three recorders are used, three records will be impressed, and the recording speed will be three feet per second. Four recorders with a speed of three feet per second would mean a recording speed of four feet per second, and so on.

It is obviously necessary to employ some means whereby only that recorder that is actually impressing its own specific record is in actual operation at any given time, all others being temporarily eliminated from activity. A very satisfactory method of accomplishing this is by the use of electricity, and this will now be described. Other methods will be described later. For this purpose, the commutator 6, Figure 2, is adjustably attached to the shaft, by means of set screws, or the like in such a position that brush 7 cuts out of circuit the recorder or recorders not functioning, and connecting only the recorder that is functioning. The commutator is shown in this case provided with two segments, 6*a* and 6*b* one being attached by wire 9 to the device at the extremity of one radial arm, and the other attached by wire 8 to the other recording device. The wire 9 passes through shaft 14 which may be provided with suitable conducting passages, 9*a*. In the drawing, the radial arms, shaft, etc., form part of the circuit, in which case only one brush 7 is necessary.

In Figures 1 and 2, the radial arms 2 are provided with simple electrical contacting brushes, for the purpose of electrically reproducing a photographic sound record described in my Patent Number 1,698,536. The two contact brushes are shown at 15. Figure 3, however, shows a radial arm provided with an electrically operated, mechanical sound reproducer 17, provided with the stylus 18. The wire 8 and the metal body of the apparatus connects this device with the external reproducing circuit.

However, wires may be used throughout for the circuit connections, and also more than one brush may be used in connection with the commutator. Besides the adjustment of the position of the commutator on the shaft, obviously the brush 7 may be attached to a movable support, as is usual in electrical machinery, whereby it also may be moved to the most favorable position to obtain the best results.

The operation of the apparatus is perfectly simple. A device similar to that shown in Figure 1 may be attached to a camera or projector, and so connected that sprocket 13 is driven at standard motion picture feed, whereupon the recorder or re-

producer will move in the opposite direction at the same speed (if but two recorders are used), with the result that the recording or reproducing speed is double that of the film, or about two feet per second.

The large sprocket wheel 1 is not fixed to the shaft 14, but is permitted to revolve freely upon it, and is held in position by the disks 12 and 12', which are fixed firmly to the shaft, and which allow just sufficient play to let wheel 1 revolve freely without vibration. In the drawings, this wheel is shown as being operated by the film as it is drawn through the picture machine. However, a special gearing could be provided to move it directly, if desired.

Strong emphasis is placed on the recording or reproducing apparatus, of which Figure 3 is an illustration of the reproducer. This consists of a stylus operated by a telephone receiver to produce the sound record, and a stylus operating a microphone to reproduce it. This arrangement permits of electrical connections throughout, permitting the use of a commutator, as well as the actual reproduction of the sound record at a distance from the reproducer 44, Fig. 15, such as for instance at a projection screen 41. Moreover, the use of microphones 48 or the like in the camera 47 permits the use of special electrical apparatus 45, not otherwise available, whereby amplification of the sound record may be attained. Such amplifying means 43 are also available in the reproduction of the sound record by the reproducing apparatus indicated at 44, Fig. 15. The alternate connecting and disconnecting of the recorders is also more effectively accomplished by the employment of an electrical commutator. The set screw 16 rigidly fastens the disk 12 to shaft 14. Recorder 17 is detachable from the radial arm.

Figure 4 shows a photographic recorder 21, consisting of a small tungsten incandescent tubular lamp attached to the extremity of the radial member. It is firmly held in position by the screw 19, while electrical connection is made by the wire 8 and conducting metallic body of the arm. The radial arm may be detached from the disk by unscrewing the threaded end 20 out of the corresponding socket. Any type of sound recorder may thus be attached to the radial arm. The term radial member may be construed to mean not only the mechanical device but also a device that is partly made up of a light beam, which is directed by proper apparatus toward the moving film to chemically alter it. One readily sees that the invention is not concerned with any specific type of sound recording, but with a means of recording sound at a speed that is greater than that of the moving medium upon which the sound is recorded.

If it is desired to record or reproduce without the use of electricity, recourse may be had to the device illustrated in Figures 5, 6 and 7. Here the film is wound upon the revolving film carrier as before. The shaft 14 is made hollow. The recorders 22 connect with the hollow shaft by means of the hollow radial members 23, having the flexible element 24, which may be either a section of rubber tubing or the like, or a sliding joint; this is designed to permit of the recorders 22 being lifted in turn from the surface of the film, by operation of the connections 25 provided with the shoes 26, which coact with the stationary cam 27. The cam is stationary, while the arms revolve. Gear wheel 3 is attached to the shaft 14, which is provided with the passage 34. External connection is made by means of a swivel or other flexible joint, which permits turning but is sufficiently sound tight. The action of spring 28 holds the shoes 26 in firm contact with the cam 27. Wheel 13 moves the film and toothed gear wheel 3, 4 and 5 move the radial members in the opposite direction as in Figure 1. It is to be understood that actual contact with the film is only made through part of the circumference of film carrier 1, namely the lower part shown in Figure 6. The radial member lifts the recorder completely away from the film surface when it reaches the upper part of the circumference, as shown in Figure 6; no trouble is occasioned by the ravelling and unravelling of the film at the point where they leave or arrive at the rotating member. The exact contour of the cam shown is not implied in the drawings, as it may be made in many forms other than that shown at 27, Figure 7.

Another modification, whereby the film is in contact with both recorders or reproducers at all times, commutation being made by means of a valve arrangement, is shown in Figures 8 and 9. A disk 30 is rigidly attached to the radial arms 23, and communicates therewith by means of the openings 31. Above this disk is placed the stationary valve body 33 having the passage 32 located directly over the disk 30. Passage 32 communicates with sound tube 34. Tubes 23 are isolated from each other by diaphragm, or partition 35. Moreover, those tubes are rigidly attached to shaft 14 as above described. It can be readily seen that as the radial tubes revolve together with disk 30, openings 31 communicate alternately with passage 32, so that at any given time, but one sound device is recording or reproducing. In other words, only the functioning recorder is in action.

Many other mechanical arrangements are possible, but it is not deemed necessary to illustrate them here. Where the radial members are made up of reciprocating parts, it is best to provide guides as shown at 29.

Figure 10, *a*, illustrates diagrammatically the arrangements of the radial members when three are used, the speed being double that of the film by suitable gearing; the recording speed is thus three times the film speed. Figure 10 *b* illustrates the arrangement diagrammatically when four radial members are employed; their speed is three times that of the film, the recording speed being four times that of the film. Figure 11 is also a diagrammatic view showing a method of using four radial members, two being one each side of the film and coacting therewith; the recording speed in such case is also four times film speed. Figure 12 illustrates the fact that the recording diaphragm may be located at the center of the revolving film carrier, while the styli extend as radial arms. All of those figures merely illustrate different ways in which the fundamental principles underlying the invention may be carried out. The invention embraces them and many other modifications.

If the photographic method of reproducing is used, the selenium cell or equivalent 53, Fig. 17, can be made in the form of slit arranged in a semi-circle, corresponding to the form of the curved film. The effective part of the cell will be thus in the form of a long, narrow slit over which the light recorder on the radial arm 52, illustrated in detail in Fig. 4, passes longitudinally. Consequently, as the light is not stationary, a heat-absorbing means will be unnecessary.

By making the rotating film carrier 1 of very large diameter, the styli would remain in contact with the film for a much longer period. Also the possibility of the commutation of the different reproducers being audibly detected by the audience would be minimized.

Each recorder contacts with the precise portion of the film as regards right or left throughout the length of the film. As the latter is held rigidly in position, the proper sound reproducer finds its corresponding groove with absolute precision.

By making shaft 14 sufficiently long and adding one or more extra arms similar to 2 and 2′ and spacing them equidistantly on the shaft, and changing the gearing to rotate them at the proper speed, which is a multiple of the film speed, the sound recording speed is thus increased. The electrical connections and commutator must be also adjusted to correspond. The flexibility of the mechanism is obvious.

In order to offer a firm support to the film while the recorder or reproducer is passing over its surface, an endless belt 57, Fig. 17 made of a substance approximating the provided with a slack adjuster or idler consisting, for instance of a weighted pulley 61, the weight being indicated at 62.

Wheels 3, 4 and 5 are supported on any suitable frame work 42. Power is preferably applied to 5 or 13, so as to move the film at standard motion picture speed. The film, however, may be simply pulled through the apparatus by other sprocket wheels, such as indicated at 49 in Figure 1.

Laterally undulating sound recording has been very successful commercially, and as there is room for many such record grooves on the margin of a moving picture film, the invention offers a means of placing several such records there utilizing them to reproduce sounds. Moreover, by this means a recording speed is available that is in excess of that used in commercial sound recording.

An advantage of electrical commutation is that a record can come into contact with the film for a time before it is actually brought into electrical connection.

Having thus described my invention, I claim as new and desire to secure by Letters Patent:

1. Phonographic apparatus adapted for sound records on film, comprising a means including a large wheel directly supporting that portion of the film laterally adjacent to that portion of the sound record from which sound is reproduced, whereby said apparatus operates in a uniform manner, the sound record portion being unsupported thereby.

2. A phonographic apparatus adapted for operation with motion picture film having a sound record thereon comprising a large wheel in cooperative relation with the film adjacent the recording or reproducing point whereby said apparatus operates in a uniform manner and means independent of said wheel for pulling the film through the said apparatus.

3. Phonographic apparatus adapted to operate with film having a photographic sound record thereon comprising a large wheel in cooperative relation with the film laterally adjacent the operational point, whereby said apparatus operates in a uniform manner, the sound record portion being unsupported thereby and means independent of said wheel for pulling the film through the said apparatus.

4. Phonographic apparatus adapted for operation with film having a photographic sound record thereon comprising a sound recording or reproducing means and a large wheel in cooperative relation with said film adjacent the said means for recording or reproducing, whereby said apparatus operates in a uniform manner and additional

ture film having a sound record thereon, said wheel being relatively large, whereby said apparatus operates in a uniform manner, sound reproducing means in cooperative relation to said record adjacent to said wheel, and means independent of said wheel for drawing said film through said apparatus.

6. A phonographic apparatus adapted to operate with film having a photographic sound record thereon comprising a large wheel in cooperative relation with the film adjacent the recording or reproducing point and means uniformly contacting with the portion of the film upon said wheel for maintaining the same in uniform cooperative relation with said wheel.

7. In a sound reproducer for motion picture film having a sound record adjacent the edge thereof, in combination, a large wheel adapted to support the film adjacent the reproduction point, whereby said apparatus operates in a uniform manner means for maintaining the film on the wheel with the sound record over-hanging the edge thereof, sound reproducing means adapted to cooperate with the sound record on the over-hanging edge of said film, and means independent of said wheel for drawing said film through said apparatus.

8. Phonographic apparatus adapted to operate with photographic sound records on film comprising a large wheel in cooperative relation with the film adjacent the operational point whereby said apparatus operates in a uniform manner, means comprising a yieldable idler for maintaining said film in cooperative relation with said wheel, whereby said film is firmly supported upon said wheel, and means independent of said wheel for pulling the film through the said apparatus.

9. In a sound reproducer for motion picture film having a sound record adjacent the edge thereof, in combination, a large wheel adapted to support the film at the reproduction point, whereby said apparatus operates in a uniform manner and yieldable means including a belt passing over the film upon said wheel and a yieldable idler maintaining said belt under tension for maintaining the film on the wheel with the sound record overhanging the edge thereof.

ALOYSIUS J. CAWLEY.

Desirability for uniform lineation frame, no matter how sound recorded

Dragonnier 1381

Figure 10, *a*, illustrates diagrammatically the arrangements of the radial members when three are used, the speed being double that of the film by suitable gearing; the recording speed is thus three times the film speed. Figure 10 *b* illustrates the arrangement diagrammatically when four radial members are employed; their speed is three times that of the film, the recording speed being four times that of the film. Figure 11 is also a diagrammatic view showing a method of using four radial members, two being one each side of the film and coacting therewith; the recording speed in such case is also four times film speed. Figure 12 illustrates the fact that the recording diaphragm may be located at the center of the revolving film carrier, while the styli extend as radial arms. All of those figures merely illustrate different ways in which the fundamental principles underlying the invention may be carried out. The invention embraces them and many other modifications.

If the photographic method of reproducing is used, the selenium cell or equivalent 53, Fig. 17, can be made in the form of slit arranged in a semi-circle, corresponding to the form of the curved film. The effective part of the cell will be thus in the form of a long, narrow slit over which the light recorder on the radial arm 52, illustrated in detail in Fig. 4, passes longitudinally. Consequently, as the light is not stationary, a heat-absorbing means will be unnecessary.

By making the rotating film carrier 1 of very large diameter, the styli would remain in contact with the film for a much longer period. Also the possibility of the commutation of the different reproducers being audibly detected by the audience would be minimized.

Each recorder contacts with the precise portion of the film as regards right or left throughout the length of the film. As the latter is held rigidly in position, the proper sound reproducer finds its corresponding groove with absolute precision.

By making shaft 14 sufficiently long and adding one or more extra arms similar to 2 and 2′ and spacing them equidistantly on the shaft, and changing the gearing to rotate them at the proper speed, which is a multiple of the film speed, the sound recording speed is thus increased. The electrical connections and commutator must be also adjusted to correspond. The flexibility of the mechanism is obvious.

In order to offer a firm support to the film while the recorder or reproducer is passing over its surface, an endless belt 57, Fig. 17 made of a substance approximating the density of ordinary phonograph record backing material, such as waxed paper, may be arranged so as to pass around the contact roll 10 and sprocket 13. This belt may be provided with a slack adjuster or idler consisting, for instance of a weighted pulley 61, the weight being indicated at 62.

Wheels 3, 4 and 5 are supported on any suitable frame work 42. Power is preferably applied to 5 or 13, so as to move the film at standard motion picture speed. The film, however, may be simply pulled through the apparatus by other sprocket wheels, such as indicated at 49 in Figure 1.

Laterally undulating sound recording has been very successful commercially, and as there is room for many such record grooves on the margin of a moving picture film, the invention offers a means of placing several such records there utilizing them to reproduce sounds. Moreover, by this means a recording speed is available that is in excess of that used in commercial sound recording.

An advantage of electrical commutation is that a record can come into contact with the film for a time before it is actually brought into electrical connection.

Having thus described my invention, I claim as new and desire to secure by Letters Patent:

1. Phonographic apparatus adapted for sound records on film, comprising a means including a large wheel directly supporting that portion of the film laterally adjacent to that portion of the sound record from which sound is reproduced, whereby said apparatus operates in a uniform manner, the sound record portion being unsupported thereby.

2. A phonographic apparatus adapted for operation with motion picture film having a sound record thereon comprising a large wheel in cooperative relation with the film adjacent the recording or reproducing point whereby said apparatus operates in a uniform manner and means independent of said wheel for pulling the film through the said apparatus.

3. Phonographic apparatus adapted to operate with film having a photographic sound record thereon comprising a large wheel in cooperative relation with the film laterally adjacent the operational point, whereby said apparatus operates in a uniform manner, the sound record portion being unsupported thereby and means independent of said wheel for pulling the film through the said apparatus.

4. Phonographic apparatus adapted for operation with film having a photographic sound record thereon comprising a sound recording or reproducing means and a large wheel in cooperative relation with said film adjacent the said means for recording or reproducing, whereby said apparatus operates in a uniform manner and additional means for feeding the film through said apparatus.

5. In an apparatus of the class described a wheel adapted to support a motion pic-

ture film having a sound record thereon, said wheel being relatively large, whereby said apparatus operates in a uniform manner, sound reproducing means in cooperative relation to said record adjacent to said wheel, and means independent of said wheel for drawing said film through said apparatus.

6. A phonographic apparatus adapted to operate with film having a photographic sound record thereon comprising a large wheel in cooperative relation with the film adjacent the recording or reproducing point and means uniformly contacting with the portion of the film upon said wheel for maintaining the same in uniform cooperative relation with said wheel.

7. In a sound reproducer for motion picture film having a sound record adjacent the edge thereof, in combination, a large wheel adapted to support the film adjacent the reproduction point, whereby said apparatus operates in a uniform manner means for maintaining the film on the wheel with the sound record over-hanging the edge thereof, sound reproducing means adapted to cooperate with the sound record on the over-hanging edge of said film, and means independent of said wheel for drawing said film through said apparatus.

8. Phonographic apparatus adapted to operate with photographic sound records on film comprising a large wheel in cooperative relation with the film adjacent the operational point whereby said apparatus operates in a uniform manner, means comprising a yieldable idler for maintaining said film in cooperative relation with said wheel, whereby said film is firmly supported upon said wheel, and means independent of said wheel for pulling the film through the said apparatus.

9. In a sound reproducer for motion picture film having a sound record adjacent the edge thereof, in combination, a large wheel adapted to support the film at the reproduction point, whereby said apparatus operates in a uniform manner and yieldable means including a belt passing over the film upon said wheel and a yieldable idler maintaining said belt under tension for maintaining the film on the wheel with the sound record overhanging the edge thereof.

ALOYSIUS J. CAWLEY.

Desirability for uniform motion picture, no matter how viewed recorded

Dragonnier 1381

1276

Sept. 29, 1931. A. J. CAWLEY 1,825,440

SOUND RECORDING OR REPRODUCING APPARATUS

Original Filed Jan. 8, 1921 4 Sheets-Sheet 1

Fig. 1

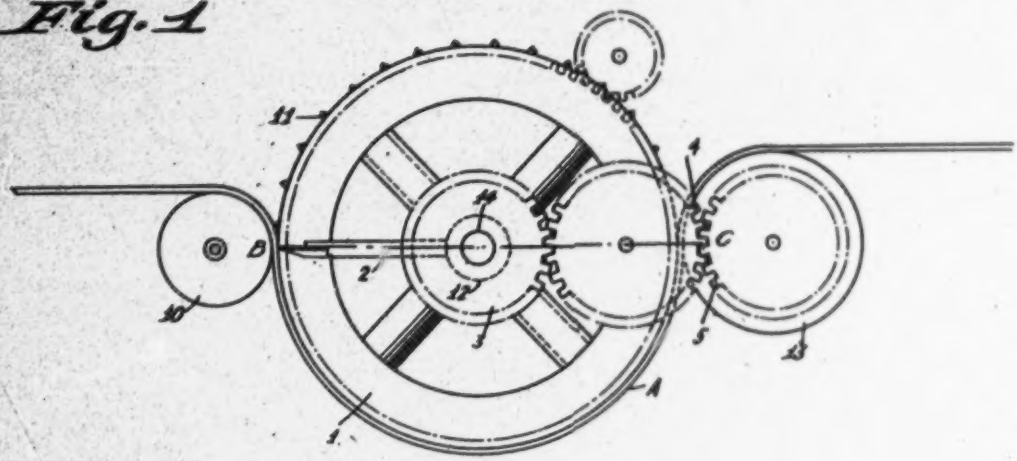


Fig. 2

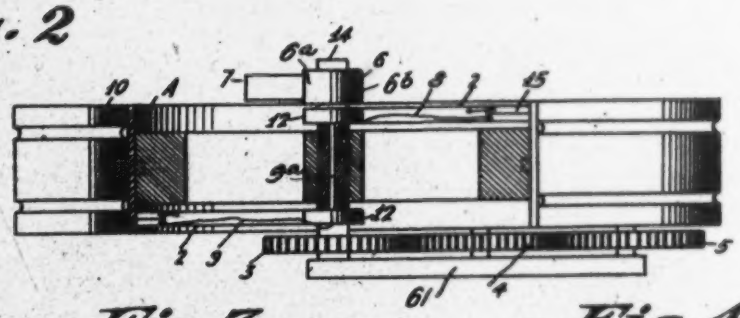


Fig. 3

Fig. 4

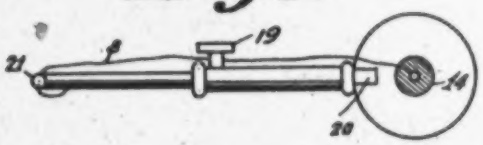


Fig. 5

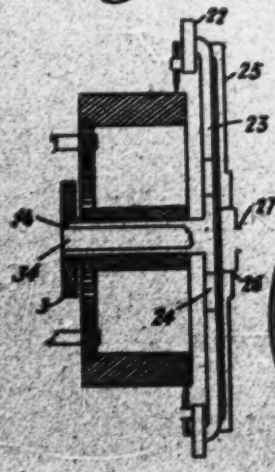


Fig. 6

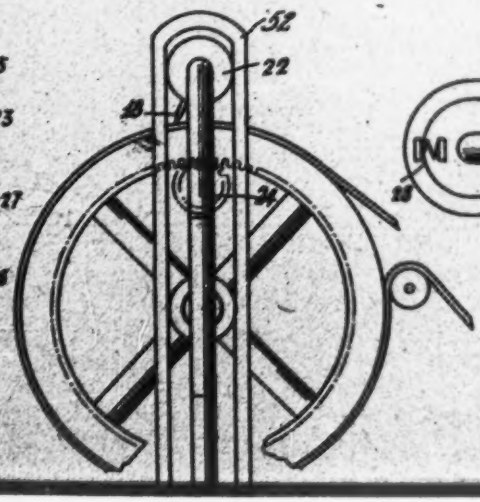
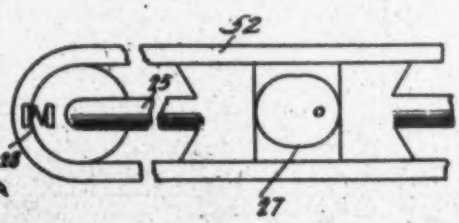


Fig. 7



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Sept. 29, 1931. A. J. CAWLEY 1,825,440

SOUND RECORDING OR REPRODUCING APPARATUS

Original Filed Jan. 8, 1921 4 Sheets-Sheet 2

Fig. 8

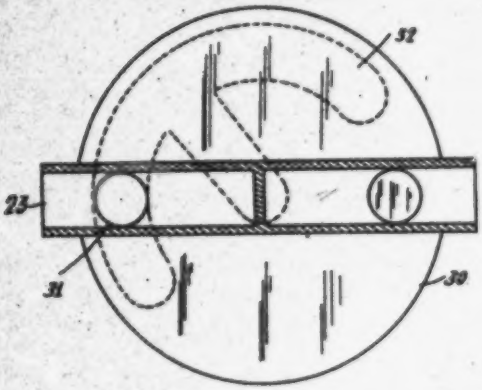


Fig. 9

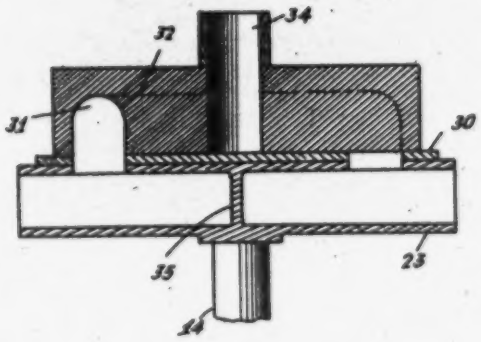


Fig. 10a

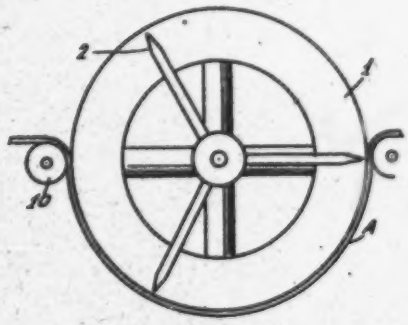


Fig. 10b

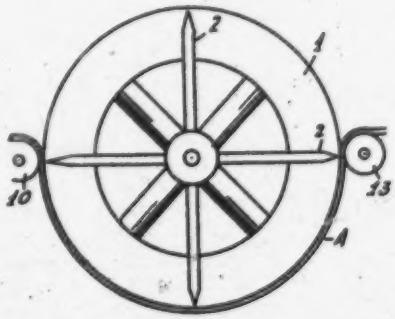


Fig. 11

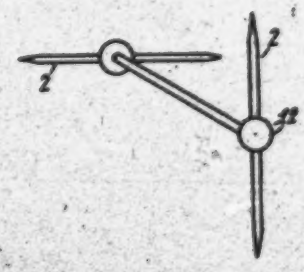
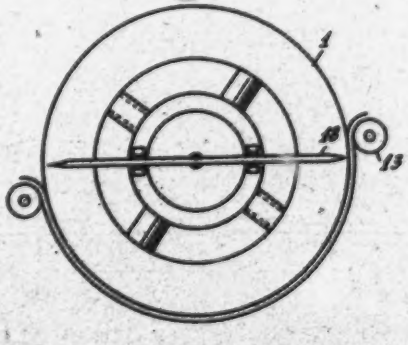


Fig. 12



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Sept. 29, 1931. A. J. CAWLEY 1,825,440

SOUND RECORDING OR REPRODUCING APPARATUS

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Fig. 8

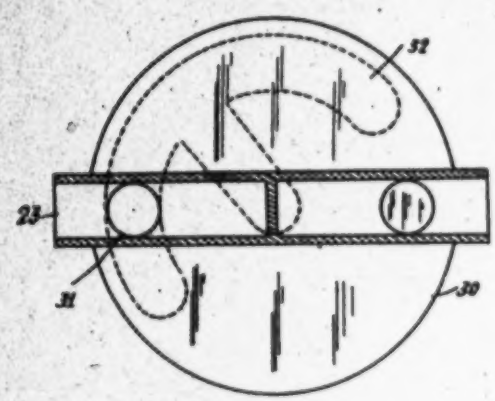


Fig. 9

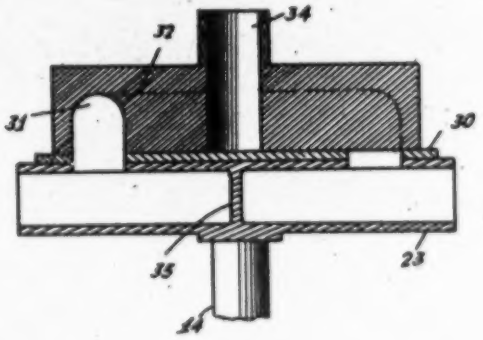


Fig. 10a

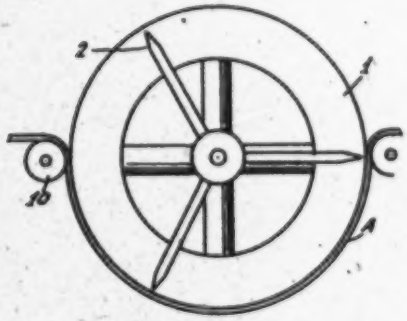


Fig. 10b

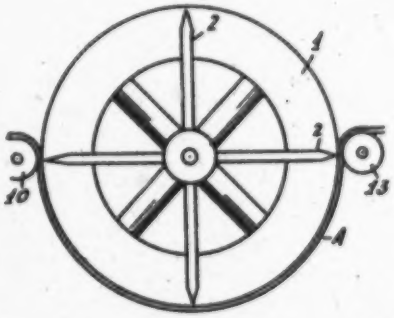


Fig. 11

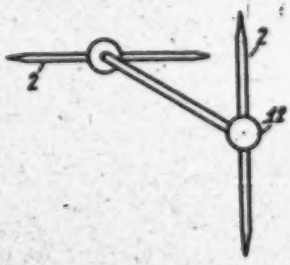
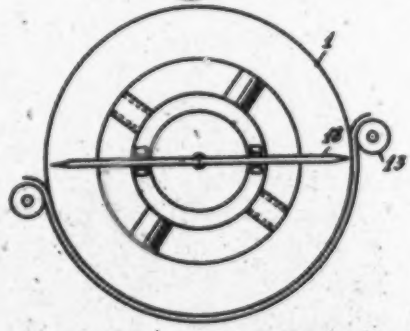


Fig. 12



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1280

Sept. 29, 1931. A. J. CAWLEY 1,825,440

SOUND RECORDING OR REPRODUCING APPARATUS

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Fig. 13

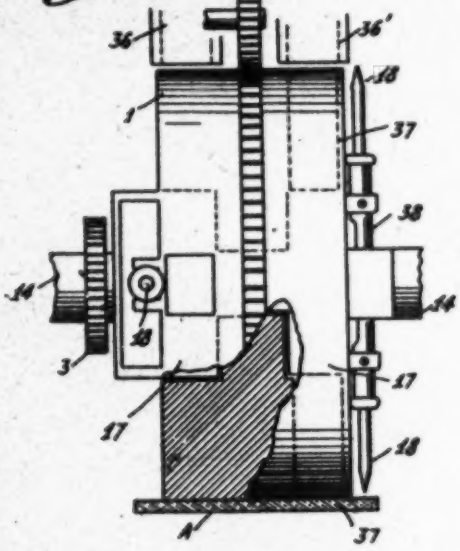


Fig. 14

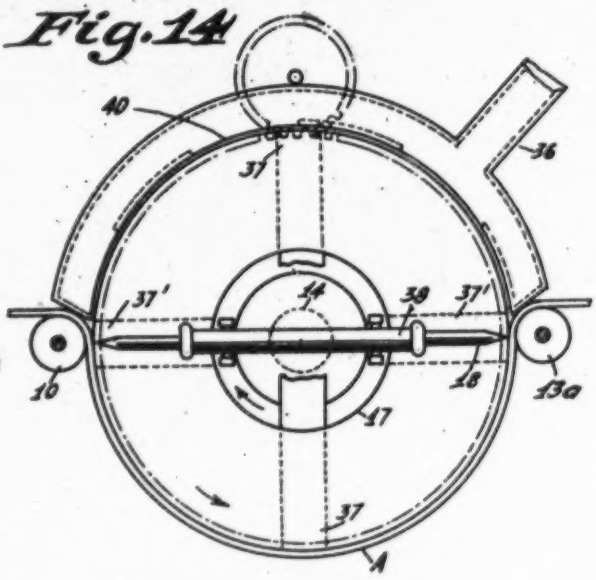


Fig. 15

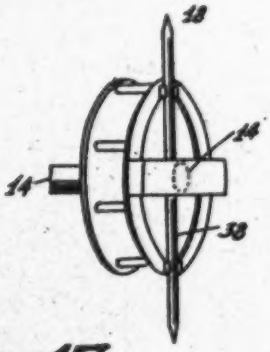


Fig. 16

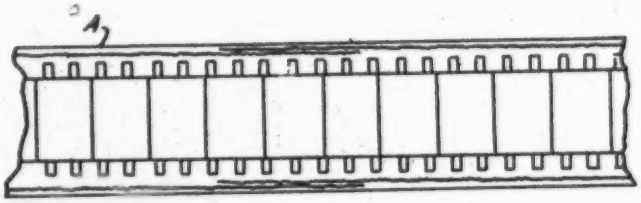


Fig. 17

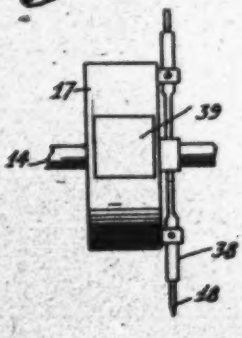
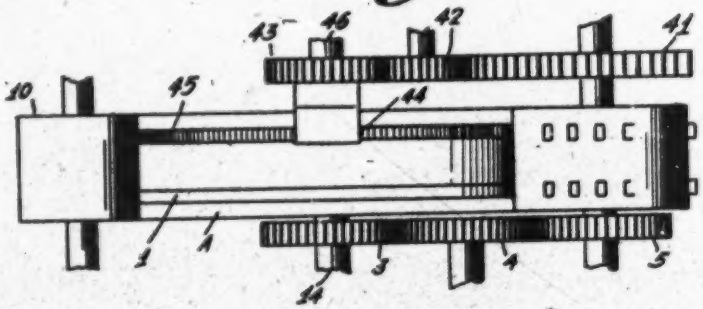


Fig. 18



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1282

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SOUND RECORDING OR REPRODUCING APPARATUS

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Fig. 19

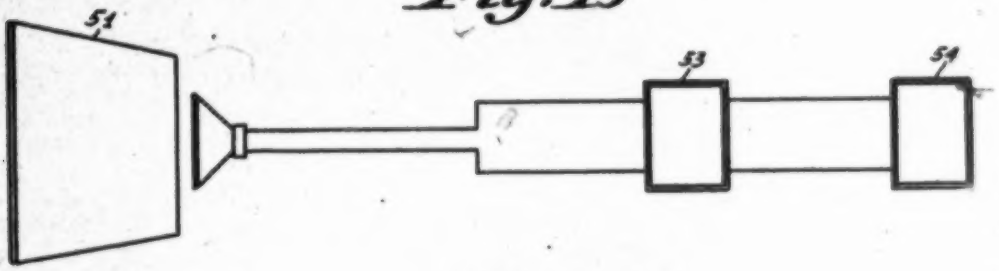
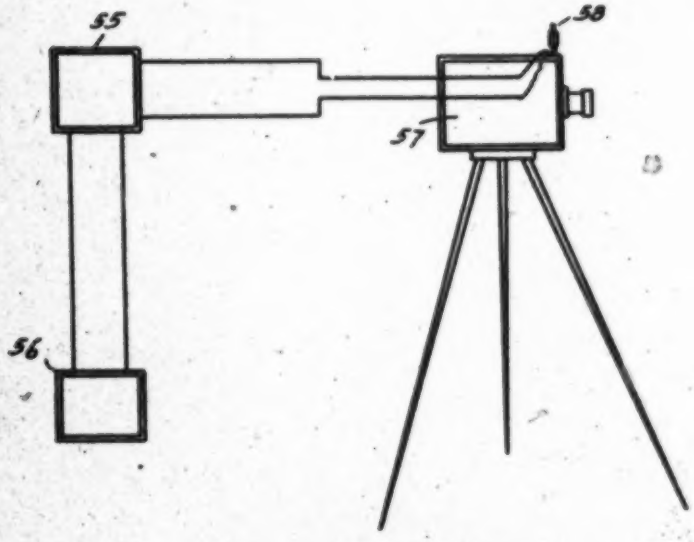


Fig. 20



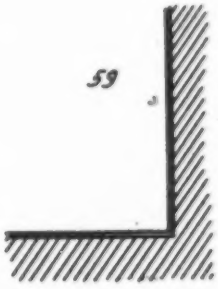
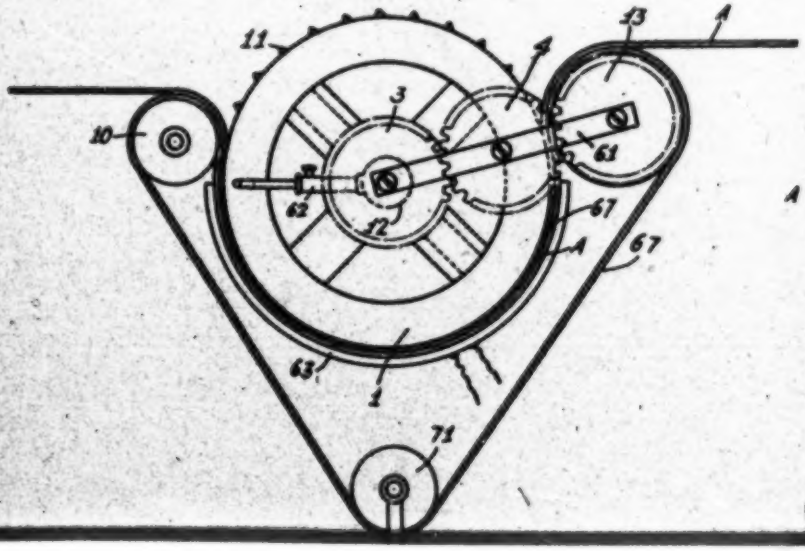


Fig. 22

Fig. 21



INVENTOR

Patented Sept. 29, 1931

1283

1,825,440

UNITED STATES PATENT OFFICE

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SOUND RECORDING OR REPRODUCING APPARATUS

Original application filed January 8, 1921, Serial No. 435,984. Divided and this application filed September 16, 1929. Serial No. 393,073.

This application is a division of my application Serial Number 435,984, filed January 8, 1921.

The invention relates generally to the method of producing sound records on motion picture films, so that sound and picture records may be synchronously reproduced, although the invention is not necessarily limited to this field.

More particularly, the invention is concerned with the recording of sound on a motion picture film at a recording speed that is much in excess of the speed of the film. An arrangement is provided whereby a recorder contacts with a film, while moving in the opposite direction thereto. The recording speed is thus equal to the sum of the speeds of the recorder and film.

A plurality of recorders are employed, which contact alternately with separate portions of the film. These recorders are placed radially at fixed intervals, and one contacts with a record surface of a given length, while the film has actually passed through but a fraction of this length. The other recorder is then in a position to contact with an equivalent length juxtaposed to, or opposite to that traversed by the first.

An electrical or mechanical arrangement is provided whereby the recorders are thrown out of operation when not recording their own specific record groove.

Arrangements are described whereby any desired sound recording speed may be obtained without any increase in the speed of the film, by simply increasing the number and speed of the recording units.

The invention is perfectly adaptable to the standard motion picture film as it exists in practice at present, and is concerned with placing sound records on the margin, or margins of such a film. This is particularly feasible if mechanical sound grooves are used, as there is room for a very large number of such records. The latter may be as would be the case, if for instance, the latter were placed across the reverse face of the film, as in such case, they would be projected upon the picture screen.

The invention, further, is not limited to mere mechanical methods of recording, but is adapted to any means, such as photographic, magnetic, or the electrical reproduction described in another application. Although the invention is not limited to any of those methods, great emphasis is placed on the method employing electrically operated sound recorders and reproducers; the recording speed that it is most desired to use with this is approximately double the film speed.

It will be noted that there are no abrupt changes in the direction of moving parts. All parts move in a uniform manner, and the apparatus as a whole is very simple. It is to be especially noted that, although the recording speed is rather high, neither the film carrier nor the recorders move at this speed, the high speed mentioned being due to the relative motion of recorder and film. This means that considerable wear is saved in the apparatus.

One can readily see that by employing a suitable number of recorders moving at a proper speed, that photographic sound recording processes requiring a speed of six feet per second may be utilized so that they may be placed on a film that is moving at the standard motion picture speed of one foot per second.

For a more complete understanding of the invention, reference is to be had to the following description and claims taken in connection with the accompanying drawings, in which like characters of reference denote corresponding parts in all the views, and in which,

Figure 1 is an elevation view showing an electrical reproducing device.

Figure 2 is a cross sectional view on line

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SOUND RECORDING OR REPRODUCING APPARATUS

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Fig. 19

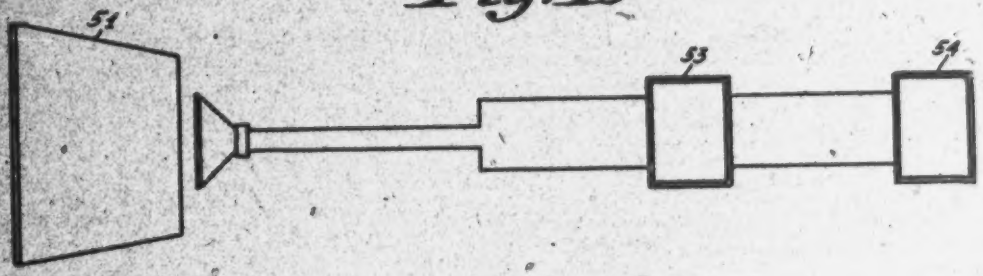


Fig. 20

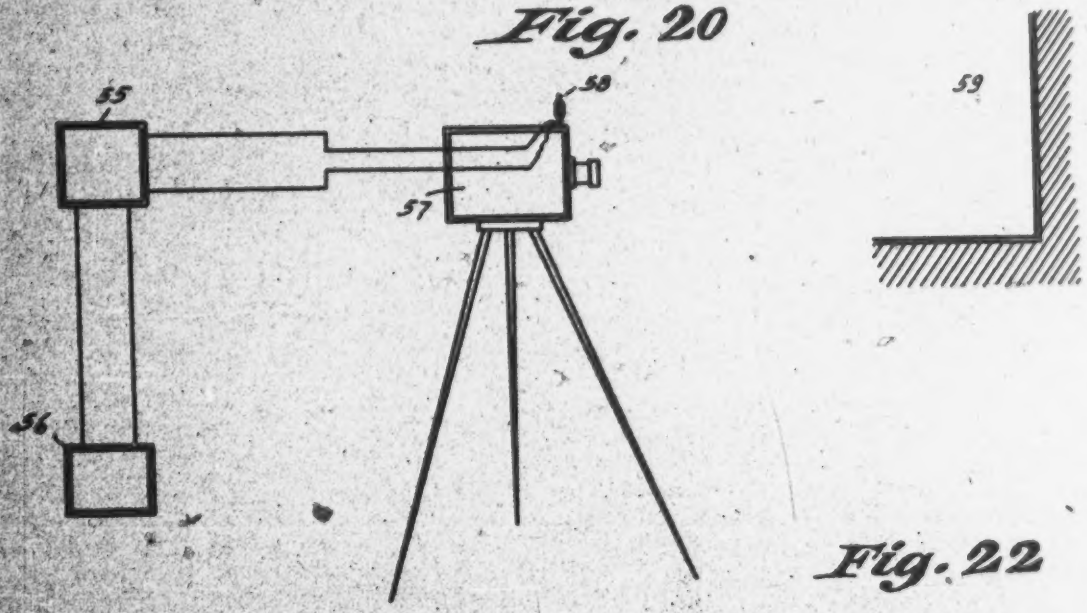


Fig. 22

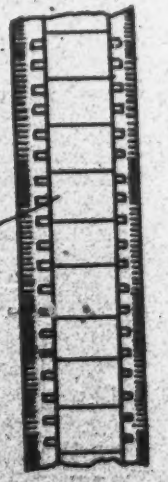
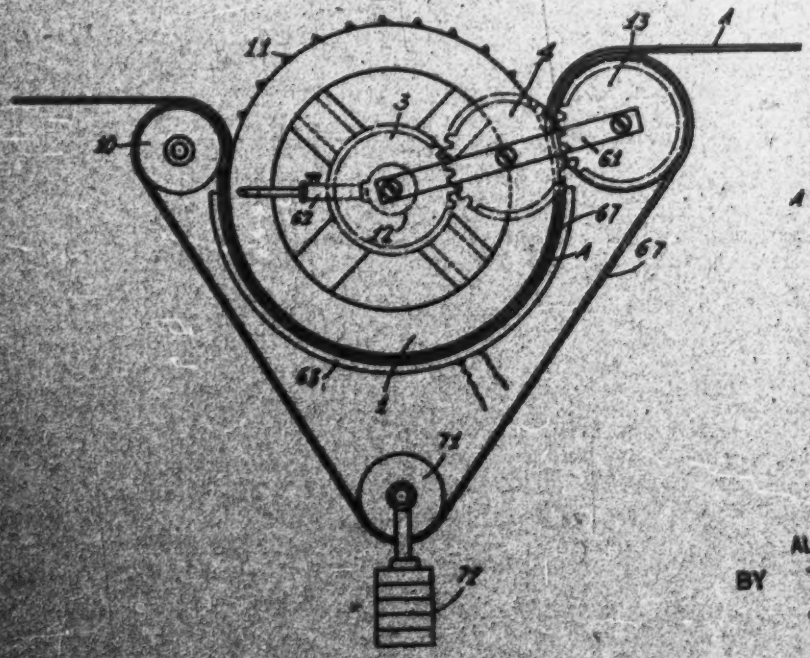


Fig. 21



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SOUND RECORDING OR REPRODUCING APPARATUS

Original application filed January 8, 1921, Serial No. 435,984. Divided and this application filed September 16, 1929. Serial No. 393,073.

This application is a division of my application Serial Number 435,984, filed January 8, 1921.

The invention relates generally to the method of producing sound records on motion picture films, so that sound and picture records may be synchronously reproduced, although the invention is not necessarily limited to this field.

More particularly, the invention is concerned with the recording of sound on a motion picture film at a recording speed that is much in excess of the speed of the film. An arrangement is provided whereby a recorder contacts with a film, while moving in the opposite direction thereto. The recording speed is thus equal to the sum of the speeds of the recorder and film.

A plurality of recorders are employed, which contact alternately with separate portions of the film. These recorders are placed radially at fixed intervals, and one contacts with a record surface of a given length, while the film has actually passed through but a fraction of this length. The other recorder is then in a position to contact with an equivalent length juxtaposed to, or opposite to that traversed by the first.

An electrical or mechanical arrangement is provided whereby the recorders are thrown out of operation when not recording their own specific record groove.

Arrangements are described whereby any desired sound recording speed may be obtained without any increase in the speed of the film, by simply increasing the number and speed of the recording units.

The invention is perfectly adaptable to the standard motion picture film as it exists in practice at present, and is concerned with placing sound records on the margin, or margins of such a film. This is particularly feasible if mechanical sound grooves are used, as there is room for a very large number of such records. The latter may be placed on one margin only, or be distributed on both margins, as hereinafter described.

As the sound records are intended to be placed on the margins of the film, there is no interference of picture and sound record as would be the case, if for instance, the latter were placed across the reverse face of the film, as in such case, they would be projected upon the picture screen.

The invention, further, is not limited to mere mechanical methods of recording, but is adapted to any means, such as photographic, magnetic, or the electrical reproduction described in another application. Although the invention is not limited to any of those methods, great emphasis is placed on the method employing electrically operated sound recorders and reproducers; the recording speed that it is most desired to use with this is approximately double the film speed.

It will be noted that there are no abrupt changes in the direction of moving parts. All parts move in a uniform manner, and the apparatus as a whole is very simple. It is to be especially noted that, although the recording speed is rather high, neither the film carrier nor the recorders move at this speed, the high speed mentioned being due to the relative motion of recorder and film. This means that considerable wear is saved in the apparatus.

One can readily see that by employing a suitable number of recorders moving at a proper speed, that photographic sound recording processes requiring a speed of six feet per second may be utilized so that they may be placed on a film that is moving at the standard motion picture speed of one foot per second.

For a more complete understanding of the invention, reference is to be had to the following description and claims taken in connection with the accompanying drawings, in which like characters of reference denote corresponding parts in all the views, and in which,

Figure 1 is an elevation view showing an electrical reproducing device.

Figure 2 is a cross sectional view on line BC of the rotating film carrier.

Figure 3 is an elevational view of an electrically operated, mechanical sound recorder placed on a radial arm.

Figure 4 is a plan view of a photographic

sound recorder placed on a radial arm, also illustrating the detachable nature of the latter.

Figure 5 is a plan view of a device employing mechanical recording, whereby the non-functioning recorder is raised from the film surface at the proper time.

Figure 6 is a side view of a mechanical recording arrangement.

Figure 7 is a view showing the radial arms, stationary cam and contacts for raising recorder from film surface.

Figure 8 is a plan view of the disk attached to the hollow tubes, showing the passage in the valve body above.

Figure 9 is a cross sectional view of the valve body, showing the communicating passages made with the tubes below.

Figure 10, *a* and *b*, are diagrammatic views showing the arrangements of three and four recorders, respectively.

Figure 11 is a diagrammatic view showing two recorders adapted to play on each margin of the film.

Figure 12 is an elevational view showing the recorder diaphragm placed at the center of the revolving element, with styli extending as radial arms.

Figure 13 is an elevational view, partly in cross-section, of another embodiment of the invention. This consists of two concentrically revolving sound recorders adapted to coact with circumferential valves.

Figure 14 is a side elevational view of the device shown in Figure 13.

Figure 15 is an elevational view of a sound box capable of use in the device of Figure 14.

Figure 16 is an plan view of a motion picture film having a plurality of high speed sound record grooves on its margin.

Figure 17 is an elevational view of a sound box also intended for use with the device of Figure 14.

Figure 18 is a plan view of an arrangement for rigidly connecting and moving wheel 1.

Figure 19 is a diagrammatic illustration of a reproducing apparatus provided with an amplifier and in cooperative relation to a projection screen.

Figure 20 is a diagrammatic illustration of the arrangement of apparatus for recording.

Figure 21 corresponds to Figure 1 but includes the photoelectric reproducer of Figure 4 and additional means for supporting the film.

Figure 22 corresponds to Figure 16 but

around the large sprocket wheel 1, contact roll 10 holding it in engagement with sprocket teeth 11, as shown in Figure 1. The member 1 is obviously not necessarily a wheel, but may be a drum or cylinder as shown in Figs. 13, 14 and 17, or any equivalent cylindrical member. The film then passes over a smaller sprocket 13, to which is rigidly attached the gear wheel 5. It is obvious that sprocket 1 pulls the film forward. Wheel 5 communicates motion through wheel 4 to wheel 3, which is rigidly attached to shaft 14, which carries the radial arms 2, also rigidly attached to it, and bearing recording or reproducing means at their extremities. Toothed gear wheels 3, 4 and 5 are so proportioned that the devices at the extremities of the radial arms move, while in contact with the film surfaces, at a speed which is equal to (when two arms are employed) that of the film, but in the opposite direction. Obviously, the relative speeds of film and recorder passing over it, will be equal to the sum of their individual speeds. Consequently, if the speed of the film is one foot per second, the recording speed is twice this, or two feet per second. One can readily see that if the gearing is so arranged that the recorders move at a speed double that of the film, and three recorders are used, three records will be impressed, and the recording speed will be three feet per second. Four recorders with a speed of three feet per second would mean a recording speed of four feet per second, and so on.

It is obviously necessary to employ some means whereby only that recorder that is actually impressing its own specific record is in actual operation at any given time, all others being temporarily eliminated from activity. A very satisfactory method of accomplishing this is by the use of electricity, and this will now be described. Other methods will be described later. For this purpose, the commutator 6, Figure 2, is adjustably attached to the shaft, by means of set screws, or the like in such a position that brush 7 cuts out of circuit the recorder or recorders not functioning, and connecting only the recorder that is functioning. The commutator is shown in this case provided with two segments, 6*a* and 6*b* one being attached by wire 9 to the device at the extremity of one radial arm, and the other attached by wire 8 to the other recording device. The wire 9 passes through shaft 14 which may be provided with suitable conducting passages 9*a*. In the drawings,

producing a photographic sound record as described in my Patent Number 1,698,536. The two contact brushes are shown at 15. Figure 3, however, shows a radial arm provided with an electrically operated, mechanical sound reproducer 17, provided with the stylus 18. The wire 8 and the metal body of the apparatus connects this device with the external reproducing circuit.

However, wires may be used throughout for the circuit connections, and also more than one brush may be used in connection with the commutator. Besides the adjustment of the position of the commutator on the shaft, obviously the brush 7 may be attached to a movable support, as is usual in electrical machinery, whereby it also may be moved to the most favorable position to obtain the best results.

The operation of the apparatus is perfectly simple. A device similar to that shown in Figure 1 may be attached to a camera or projector, and so connected that sprocket 1 is driven at standard motion picture feed, whereupon the recorder or reproducer will move in the opposite direction at the same speed (if but two recorders are used), with the result that the recording or reproducing speed is double that of the film, or about two feet per second.

The large sprocket wheel 1 is not fixed to the shaft 14, but is permitted to revolve freely upon it, and is held in position by the disks 12 and 12', which are fixed firmly to the shaft, and which allow just sufficient play to let wheel 1 revolve freely without vibration. In the drawings, this wheel is shown as being driven by proper gearing.

Strong emphasis is placed on the recording or reproducing apparatus, of which Figure 3 is an illustration of the reproducer. This consists of a stylus operated by a telephone receiver to produce the sound record, and a stylus operating a microphone to reproduce it. This arrangement permits of electrical connections throughout, permitting the use of a commutator, as well as the actual reproduction of the sound record at a distance from the reproducer 54, Fig. 19, such as for instance at a projection screen 51. Moreover, the use of microphones 58 or the like in the camera 57 permits the use of special electrical apparatus 55, not otherwise available, whereby amplification of the sound record may be attained. Such amplifying means 53 are also available in the reproduction of the sound record by the reproducing apparatus indicated at 54, Fig. 19. The alternate connecting and disconnection of the [illegible]

21, consisting of a small tungsten incandescent tubular lamp attached to the extremity of the radial member. It is firmly held in position by the screw 19, while electrical connection is made by the wire 8 and conducting metallic body of the arm. The radial arm may be detached from the disk by unscrewing the threaded end 20 out of the corresponding socket. Any type of sound recorder may thus be attached to the radial arm. The term radial member may be construed to mean not only the mechanical device but also a device that is partly made up of a light beam, which is directed by proper apparatus toward the moving film to chemically alter it. One readily sees that the invention is not concerned with any specific type of sound recording, but with a means of recording sound at a speed that is greater than that of the moving medium upon which the sound is recorded.

If it is desired to record or reproduce without the use of electricity, recourse may be had to the device illustrated in Figures 5, 6 and 7. Here the film is wound upon the revolving film carrier as before. The shaft 14 is made hollow. The recorders 22 connect with the hollow shaft by means of the hollow radial members 23, having the flexible element 24, which may be either a section of rubber tubing or the like, or a sliding joint; this is designed to permit of the recorders 22 being lifted in turn from the surface of the film, by operation of the connections 25 provided with the shoes 26, which coact with the stationary cam 27. The cam is stationary, while the arms revolve. Gear wheel 3 is attached to the shaft 14, which is provided with the passage 34. External connection is made by means of a swivel or other flexible joint, which permits turning but is sufficiently sound tight. The action of spring 28 holds the shoes 26 in firm contact with the cam 27. Wheel 1 moves the film and toothed gear wheel 3, 4 and 5 move the radial members in the opposite direction as in Figure 1. It is to be understood that actual contact with the film is only made through part of the circumference of film carrier 1, namely the lower part shown in Figure 6. The radial member lifts the recorder completely away from the film surface when it reaches the upper part of the circumference, as shown in Figure 6; no trouble is occasioned by the ravelling and unravelling of the film at the point where they leave or arrive at the rotating member. The exact contour of the cam shown is not implied in the drawings, as it may

sound recorder placed on a radial arm, also illustrating the detachable nature of the latter.

Figure 5 is a plan view of a device employing mechanical recording, whereby the non-functioning recorder is raised from the film surface at the proper time.

Figure 6 is a side view of a mechanical recording arrangement.

Figure 7 is a view showing the radial arms, stationary cam and contacts for raising recorder from film surface.

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Figure 15 is an elevational view of a sound box capable of use in the device of Figure 14.

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Figure 18 is a plan view of an arrangement for rigidly connecting and moving wheel 1.

Figure 19 is a diagrammatic illustration of a reproducing apparatus provided with an amplifier and in cooperative relation to a projection screen.

Figure 20 is a diagrammatic illustration of the arrangement of apparatus for recording.

Figure 21 corresponds to Figure 1 but includes the photoelectric reproducer of Figure 4 and additional means for supporting the film.

Figure 22 corresponds to Figure 16 but shows the film as having two photographic sound records instead of four grooves.

There are many ways of carrying out the invention, and although certain structures will be described in detail, the invention is not limited to them. The film A is passed around the large sprocket wheel 1, contacting roll 10 holding it in engagement with sprocket teeth 11, as shown in Figure 1. The member 1 is obviously not necessarily a wheel, but may be a drum or cylinder as shown in Figs. 13, 14 and 17, or any equivalent cylindrical member. The film then passes over a smaller sprocket 13, to which is rigidly attached the gear wheel 5. It is obvious that sprocket 1 pulls the film forward. Wheel 5 communicates motion through wheel 4 to wheel 3, which is rigidly attached to shaft 14, which carries the radial arms 2, also rigidly attached to it, and bearing recording or reproducing means at their extremities. Toothed gear wheels 3, 4 and 5 are so proportioned that the devices at the extremities of the radial arms move, while in contact with the film surfaces, at a speed which is equal to (when two arms are employed) that of the film, but in the opposite direction. Obviously, the relative speeds of film and recorder passing over it, will be equal to the sum of their individual speeds. Consequently, if the speed of the film is one foot per second, the recording speed is twice this, or two feet per second. One can readily see that if the gearing is so arranged that the recorders move at a speed double that of the film, and three recorders are used, three records will be impressed, and the recording speed will be three feet per second. Four recorders with a speed of three feet per second would mean a recording speed of four feet per second, and so on.

It is obviously necessary to employ some means whereby only that recorder that is actually impressing its own specific record is in actual operation at any given time, all others being temporarily eliminated from activity. A very satisfactory method of accomplishing this is by the use of electricity, and this will now be described. Other methods will be described later. For this purpose, the commutator 6, Figure 2, is adjustably attached to the shaft, by means of set screws, or the like in such a position that brush 7 cuts out of circuit the recorder or recorders not functioning, and connecting only the recorder that is functioning. The commutator is shown in this case provided with two segments, 6*a* and 6*b* one being attached by wire 9 to the device at the extremity of one radial arm, and the other attached by wire 8 to the other recording device. The wire 9 passes through shaft 14 which may be provided with suitable conducting passages 9*a*. In the drawings, the radial arms, shaft, etc., form part of the circuit, in which case only one brush 7 is necessary.

In Figures 1 and 2, the radial arms 2 are provided with simple electrical contacting brushes, for the purpose of electrically re-

producing a photographic sound record as described in my Patent Number 1,698,536. The two contact brushes are shown at 15. Figure 3, however, shows a radial arm provided with an electrically operated, mechanical sound reproducer 17, provided with the stylus 18. The wire 8 and the metal body of the apparatus connects this device with the external reproducing circuit.

However, wires may be used throughout for the circuit connections, and also more than one brush may be used in connection with the commutator. Besides the adjustment of the position of the commutator on the shaft, obviously the brush 7 may be attached to a movable support, as is usual in electrical machinery, whereby it also may be moved to the most favorable position to obtain the best results.

The operation of the apparatus is perfectly simple. A device similar to that shown in Figure 1 may be attached to a camera or projector, and so connected that sprocket 1 is driven at standard motion picture feed, whereupon the recorder or reproducer will move in the opposite direction at the same speed (if but two recorders are used), with the result that the recording or reproducing speed is double that of the film, or about two feet per second.

The large sprocket wheel 1 is not fixed to the shaft 14, but is permitted to revolve freely upon it, and is held in position by the disks 12 and 12', which are fixed firmly to the shaft, and which allow just sufficient play to let wheel 1 revolve freely without vibration. In the drawings, this wheel is shown as being driven by proper gearing.

Strong emphasis is placed on the recording or reproducing apparatus, of which Figure 3 is an illustration of the reproducer. This consists of a stylus operated by a telephone receiver to produce the sound record, and a stylus operating a microphone to reproduce it. This arrangement permits of electrical connections throughout, permitting the use of a commutator, as well as the actual reproduction of the sound record at a distance from the reproducer 54, Fig. 19, such as for instance at a projection screen 51. Moreover, the use of microphones 58 or the like in the camera 57 permits the use of special electrical apparatus 55, not otherwise available, whereby amplification of the sound record may be attained. Such amplifying means 53 are also available in the reproduction of the sound record by the reproducing apparatus indicated at 54, Fig. 19. The alternate connecting and disconnecting of the recorders is also more effectively accomplished by the employment of an electrical commutator. The set screw 16 rigidly fastens the disk 12 to shaft 14. Recorder 17 is detachable from the radial arm.

Figure 4 shows a photographic recorder 21, consisting of a small tungsten incandescent tubular lamp attached to the extremity of the radial member. It is firmly held in position by the screw 19, while electrical connection is made by the wire 8 and conducting metallic body of the arm. The radial arm may be detached from the disk by unscrewing the threaded end 20 out of the corresponding socket. Any type of sound recorder may thus be attached to the radial arm. The term radial member may be construed to mean not only the mechanical device but also a device that is partly made up of a light beam, which is directed by proper apparatus toward the moving film to chemically alter it. One readily sees that the invention is not concerned with any specific type of sound recording, but with a means of recording sound at a speed that is greater than that of the moving medium upon which the sound is recorded.

If it is desired to record or reproduce without the use of electricity, recourse may be had to the device illustrated in Figures 5, 6 and 7. Here the film is wound upon the revolving film carrier as before. The shaft 14 is made hollow. The recorders 22 connect with the hollow shaft by means of the hollow radial members 23, having the flexible element 24, which may be either a section of rubber tubing or the like, or a sliding joint; this is designed to permit of the recorders 22 being lifted in turn from the surface of the film, by operation of the connections 25 provided with the shoes 26, which coact with the stationary cam 27. The cam is stationary, while the arms revolve. Gear wheel 3 is attached to the shaft 14, which is provided with the passage 34. External connection is made by means of a swivel or other flexible joint, which permits turning but is sufficiently sound tight. The action of spring 28 holds the shoes 26 in firm contact with the cam 27. Wheel 1 moves the film and toothed gear wheel 3, 4 and 5 move the radial members in the opposite direction as in Figure 1. It is to be understood that actual contact with the film is only made through part of the circumference of film carrier 1, namely the lower part shown in Figure 6. The radial member lifts the recorder completely away from the film surface when it reaches the upper part of the circumference, as shown in Figure 6; no trouble is occasioned by the ravelling and unravelling of the film at the point where they leave or arrive at the rotating member. The exact contour of the cam shown is not implied in the drawings, as it may be made in many forms other than that shown at 27, Figure 7.

Another modification, whereby the film is in contact with both recorders or reproducers at all times, commutation being made by means of a valve arrangement, is shown in

Figures 8 and 9. A disk 30 is rigidly attached to the radial arms 23, and communicates therewith by means of the openings 31. Above this disk is placed the stationary valve body 33 having the passage 32 located directly over the disk 30. Passage 32 communicates with sound tube 34. Tubes 23 are isolated from each other by diaphragm, or partition 35. Moreover, those tubes are rigidly attached to shaft 14 as above described. It can be readily seen that as the radial tubes revolve together with disk 30, openings 31 communicate alternately with passage 32, so that at any given time, but one sound device is recording or reproducing. In other words, only the functioning recorder is in action.

Many other mechanical arrangements are possible, but it is not deemed necessary to illustrate them here. Where the radial members are made up of reciprocating parts, it is best to provide guides as shown at 29. Figure 10, *a*, illustrates diagrammatically the arrangements of the radial members when three are used, the speed being double that of the film by suitable gearing; the recording speed is thus three times the film speed. Figure 10 *b* illustrates the arrangement diagrammatically when four radial members are employed; their speed is three times that of the film the recording speed being four times that of the film. Figure 11 is also a diagrammatic view showing a method of using four radial members, two being on each side of the film and co-acting therewith; the recording speed in such case is also four times film speed. Figure 12 illustrates the fact that the recording diaphragm may be located at the center of the revolving film carrier, while the styli extend as radial arms. A type of sound recording employing centrally located sound boxes and circumferential valves is described in Figures 13 and 14. Figure 13 is a view of a device in which two concentrically revolving sound recorders are provided with two styli each, the latter being attached by means of bars 38 and 38′ that possess greater flexibility towards their centers in one plane only, while being perfectly rigid in a plane that is at right angles to this. The stylus bars carrying the styli 18 and 18′ do not vibrate in the plane of their circular motion, but may be readily vibrated in a plane at right angles to this, due to the stylus bar being flattened or thinned in the plane of motion of the bar. As shown in the drawing the stylus bars 38 and 38′ are at right angles to each other; this, however may be varied. The valves in the apparatus are shown at the surface of member 1; several and in addition, 36 and 36′ represent two of the radial valves. 37, 37′ are passages through 1 connecting the recorders with the valves at the proper time. The special stylus bars are shown at 38 and 38′. These may also be jointed, if desired. The diaphragm 54 is connected to the stylus bar 38′ by link 53.

The styli and film carrier move in opposite directions as before described, the commutation being made by means of the valves 36 and 36′, which are movable over the surface in order that they can be disposed so as to permit but one recorder to record or reproduce its own record.

In Figure 14, which is a view of the left side of Figure 13, it will be noticed that passage 37′ is just ceasing to give the record from its sound box, while 37 has just started to give its record. The opposite ends of the passages have been closed by film A. Passage 37 is communicating with opening 40, which extends for a distance of one-twelfth of the circumference of wheel 1; therefore, its corresponding stylus 18″ (Figure 13) is about to sweep from 37‴, in the lower part of the circle, to wheel 10 during the same time that passage 37 traverses the opening 40. Although stylus 18′ in the right horizontal position will pass from wheel 13*a* to 37‴ during the same period, its sound will not be heard because passage 37″ will not reach the valve opening 40″ in the upper right quadrant of the circle until stylus 18′ has reached the position of 37‴ in the lower semicircle. It will thus be seen that the arc extending from the point 37‴ in the lower semicircle to wheel 10 is the portion of the film where the sound is recorded or reproduced, the film passing through one-third of this arc, while the stylus passes over its entire length in the opposite direction. The sum of the speeds is four times film speed. If desired, the wheel 13*a* may be placed at 37, but in such case the arc between these two points should be covered by the surface of the valve, as shown in the upper semi-circle between the valve openings. This is to prevent the escape of sound to the external air. It will be noticed that film *a* covers one end of passages 37′, 37″ and 37‴, while the passage 37 communicates with the openings in the valves, such as 40. Also, since the film is held perfectly tight by means of wheels 10 and 13*a*, it will act as a spring to hold the stylus and film in contact, and it may be unnecessary to provide springs, or the like on arms 38, etc., to hold the two in contact. There is no objection to the overlapping of records, as it only means that the two records repro-

municating with 40. In this way, the two passages, such as 37 and 37′ in Figure 14 would reproduce in synchronism until 37 had achieved a full, open communication with 40, at which time 37′ would be completely cut off from its corresponding opening 40′. There will thus be a fusing together of the separate records, which will act to disguise the disconnected character of those elements and give the illusion of a single continuous record. Obviously there will always be the same area of sound passage communicating with the valve openings; when one is three quarters open, the other is one-quarter open, and so on. When one attains its full opening, the other is closed. One goes from zero to maximum during the same time that the other goes from maximum to zero. This feature will occupy the same position in fusing the separate elements into one as the persistence of vision of the optic nerve occupies in fusing the separate pictures of a motion picture film.

The sound box 17*a* for use with Figure 14 is shown in detail in Figure 15. Its sides may be entirely open as shown, while it rotates snugly in its chamber in wheel 1. The selection of the record is controlled entirely by means of passages 37, 37′, 37″ and 37‴ coacting with openings 40, 40′ and 40″. As described above, only one passage can communicate with an opening at any one time. Or, the sound box may be partly closed and provided with suitable openings, such as 39 in Figure 17. These will communicate with passages 37 and 37′, etc., only when desired, and will aid in giving a more hasty closing of passages 37 and 37′. All of those figures merely illustrate different ways in which the fundamental principles underlying the invention may be carried out. The invention embraces them and many other modifications.

If the photographic method of reproducing is used, the selenium cell or equivalent 63, Fig. 21, can be made in the form of slit arranged in a semi-circle, corresponding to the form of the curved film. The effective part of the cell will be thus in the form of a long, narrow slit over which the light recorder on the radial arm 62, illustrated in detail in Fig. 4, passes longitudinally. Consequently, as the light is not stationary, a heat-absorbing means will be unnecessary.

By making the rotating film carrier 1 of very large diameter, the styli would remain in contact with the film for a much longer period. Also the possibility of the commutation of the different reproducers being audibly detected by the audience would be minimized.

latter is held rigidly in position, the proper sound reproducer finds its corresponding groove with absolute precision.

By making shaft 14 sufficiently long and adding one or more extra arms similar to 2 and 2′ and spacing them equi-distantly on the shaft, and changing the gearing to rotate them at the proper speed, which is a multiple of the film speed, the sound recording speed is thus increased. The electrical connections and commutator must be also adjusted to correspond. The flexibility of the mechanism is obvious.

In order to offer a firm support to the film while the recorder or reproducer is passing over its surface, an endless belt 67, Fig. 21, made of a substance approximating the density of ordinary phonograph record backing material, such as waxed paper, may be arranged so as to pass around the contact roll 10 and sprocket 13. This belt may be provided with a slack adjuster or idler consisting, for instance of a weighted pulley 71, the weight being indicated at 72.

Wheels 3, 4 and 5 are supported on any suitable frame work 61. Power is preferably applied to 1, so as to move the film at standard motion picture speed.

Photographic sound recording has been very successful commercially, and as there is room for many such records on the margin of a moving picture film, the invention offers a means of placing several such records there and utilizing them to reproduce sounds. Moreover, by this means a recording speed is available that is in excess of that used in commercial sound recording.

An advantage of electrical commutation is that a record can come into contact with the film for a time before it is actually brought into electrical connection.

Having thus described my invention, I claim as new and desire to secure by Letters Patent.

1. In sound reproducing mechanism, a film having an optically varying sound record thereon, a reproducer, rotary supporting means for moving the film, means for maintaining the film on the supporting means with the sound record portion extending unsupported beyond the edge thereof, and means for driving said wheel, whereby said film will be driven at a uniform speed.

2. In an apparatus of the class described a wheel adapted to support a film having a sound record adjacent to the edge thereof with the sound record portion of the film extending beyond the edge of said wheel, said wheel being relatively large, sound reproducing means in cooperative relation to the sound record on said extending edge, and means for driving said wheel.

Figures 8 and 9. A disk 30 is rigidly attached to the radial arms 23, and communicates therewith by means of the openings 31. Above this disk is placed the stationary valve body 33 having the passage 32 located directly over the disk 30. Passage 32 communicates with sound tube 34. Tubes 23 are isolated from each other by diaphragm, or partition 35. Moreover, those tubes are rigidly attached to shaft 14 as above described. It can be readily seen that as the radial tubes revolve together with disk 30, openings 31 communicate alternately with passage 32, so that at any given time, but one sound device is recording or reproducing. In other words, only the functioning recorder is in action.

Many other mechanical arrangements are possible, but it is not deemed necessary to illustrate them here. Where the radial members are made up of reciprocating parts, it is best to provide guides as shown at 29. Figure 10, *a*, illustrates diagrammatically the arrangements of the radial members when three are used, the speed being double that of the film by suitable gearing; the recording speed is thus three times the film speed. Figure 10 *b* illustrates the arrangement diagrammatically when four radial members are employed; their speed is three times that of the film the recording speed being four times that of the film. Figure 11 is also a diagrammatic view showing a method of using four radial members, two being on each side of the film and co-acting therewith; the recording speed in such case is also four times film speed. Figure 12 illustrates the fact that the recording diaphragm may be located at the center of the revolving film carrier, while the styli extend as radial arms. A type of sound recording employing centrally located sound boxes and circumferential valves is described in Figures 13 and 14. Figure 13 is a view of a device in which two concentrically revolving sound recorders are provided with two styli each, the latter being attached by means of bars 38 and 38′ that possess greater flexibility towards their centers in one plane only, while being perfectly rigid in a plane that is at right angles to this. The stylus bars carrying the styli 18 and 18′ do not vibrate in the plane of their circular motion, but may be readily vibrated in a plane at right angles to this, due to the stylus bar being flattened or thinned in the plane of motion of the bar. As shown in the drawing the stylus bars 38 and 38′ are at right angles to each other; this, however may be varied. The valves in the apparatus are shown at the surface of member 1; several may be arranged circumferentially so that only one recorder is connected to the external circuit at a time. All reference numerals have the same meaning as heretofore, and in addition, 36 and 36′ represent two of the radial valves. 37, 37′ are passages through 1 connecting the recorders with the valves at the proper time. The special stylus bars are shown at 38 and 38′. These may also be jointed, if desired. The diaphragm 54 is connected to the stylus bar 38′ by link 53.

The styli and film carrier move in opposite directions as before described, the commutation being made by means of the valves 36 and 36′, which are movable over the surface in order that they can be disposed so as to permit but one recorder to record or reproduce its own record.

In Figure 14, which is a view of the left side of Figure 13, it will be noticed that passage 37′ is just ceasing to give the record from its sound box, while 37 has just started to give its record. The opposite ends of the passages have been closed by film A. Passage 37 is communicating with opening 40, which extends for a distance of one-twelfth of the circumference of wheel 1; therefore, its corresponding stylus 18″ (Figure 13) is about to sweep from 37‴, in the lower part of the circle, to wheel 10 during the same time that passage 37 traverses the opening 40. Although stylus 18′ in the right horizontal position will pass from wheel 13*a* to 37‴ during the same period, its sound will not be heard because passage 37″ will not reach the valve opening 40″ in the upper right quadrant of the circle until stylus 18′ has reached the position of 37‴ in the lower semicircle. It will thus be seen that the arc extending from the point 37‴ in the lower semicircle to wheel 10 is the portion of the film where the sound is recorded or reproduced, the film passing through one-third of this arc, while the stylus passes over its entire length in the opposite direction. The sum of the speeds is four times film speed. If desired, the wheel 13*a* may be placed at 37, but in such case the arc between these two points should be covered by the surface of the valve, as shown in the upper semi-circle between the valve openings. This is to prevent the escape of sound to the external air. It will be noticed that film *a* covers one end of passages 37′, 37″ and 37‴, while the passage 37 communicates with the openings in the valves, such as 40. Also, since the film is held perfectly tight by means of wheels 10 and 13*a*, it will act as a spring to hold the stylus and film in contact, and it may be unnecessary to provide springs, or the like on arms 38, etc., to hold the two in contact. There is no objection to the overlapping of records, as it only means that the two records reproduce the same sounds in synchronism for a short interval. In fact, this may be very desirable, as then it would compensate for the partial opening produced as at 37 com-

passages, such as 37 and 37′ in Figure 14 would reproduce in synchronism until 37 had achieved a full, open communication with 40, at which time 37′ would be completely cut off from its corresponding opening 40′. There will thus be a fusing together of the separate records, which will act to disguise the disconnected character of those elements and give the illusion of a single continuous record. Obviously there will always be the same area of sound passage communicating with the valve openings; when one is three quarters open, the other is one-quarter open, and so on. When one attains its full opening, the other is closed. One goes from zero to maximum during the same time that the other goes from maximum to zero. This feature will occupy the same position in fusing the separate elements into one as the persistence of vision of the optic nerve occupies in fusing the separate pictures of a motion picture film.

The sound box 17*a* for use with Figure 14 is shown in detail in Figure 15. Its sides may be entirely open as shown, while it rotates snugly in its chamber in wheel 1. The selection of the record is controlled entirely by means of passages 37, 37′, 37″ and 37‴ coacting with openings 40, 40′ and 40″. As described above, only one passage can communicate with an opening at any one time. Or, the sound box may be partly closed and provided with suitable openings, such as 39 in Figure 17. These will communicate with passages 37 and 37′, etc., only when desired, and will aid in giving a more hasty closing of passages 37 and 37′. All of those figures merely illustrate different ways in which the fundamental principles underlying the invention may be carried out. The invention embraces them and many other modifications.

If the photographic method of reproducing is used, the selenium cell or equivalent 63, Fig. 21, can be made in the form of slit arranged in a semi-circle, corresponding to the form of the curved film. The effective part of the cell will be thus in the form of a long, narrow slit over which the light recorder on the radial arm 62, illustrated in detail in Fig. 4, passes longitudinally. Consequently, as the light is not stationary, a heat-absorbing means will be unnecessary.

By making the rotating film carrier 1 of very large diameter, the styli would remain in contact with the film for a much longer period. Also the possibility of the commutation of the different reproducers being audibly detected by the audience would be minimized.

Each recorder contacts with the precise portion of the film as regards right or left throughout the length of the film. As the er sound reproducer finds its corresponding groove with absolute precision.

By making shaft 14 sufficiently long and adding one or more extra arms similar to 2 and 2′ and spacing them equi-distantly on the shaft, and changing the gearing to rotate them at the proper speed, which is a multiple of the film speed, the sound recording speed is thus increased. The electrical connections and commutator must be also adjusted to correspond. The flexibility of the mechanism is obvious.

In order to offer a firm support to the film while the recorder or reproducer is passing over its surface, an endless belt 67, Fig. 21, made of a substance approximating the density of ordinary phonograph record backing material, such as waxed paper, may be arranged so as to pass around the contact roll 10 and sprocket 13. This belt may be provided with a slack adjuster or idler consisting, for instance of a weighted pulley 71, the weight being indicated at 72.

Wheels 3, 4 and 5 are supported on any suitable frame work 61. Power is preferably applied to 1, so as to move the film at standard motion picture speed.

Photographic sound recording has been very successful commercially, and as there is room for many such records on the margin of a moving picture film, the invention offers a means of placing several such records there and utilizing them to reproduce sounds. Moreover, by this means a recording speed is available that is in excess of that used in commercial sound recording.

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2. In an apparatus of the class described a wheel adapted to support a film having a sound record adjacent to the edge thereof with the sound record portion of the film extending beyond the edge of said wheel, said wheel being relatively large, sound reproducing means in cooperative relation to the sound record on said extending edge, and means for driving said wheel.

3. In phonographic apparatus in which the sound record is formed on a film constituting an elongated carrier, the combination

of the wheel, means for rotating said wheel at uniform speed, means for feeding the film upon said wheel at one point and off therefrom at another point and causing it to adhere closely thereto without slippage between said points, and means, between which and the record carrier acoustically modulated energy is transferred, as the carrier moves past the same, coacting with the carrier when at a position on said wheel intermediate said two first named points.

4. In phonographic apparatus in which the sound record is formed on a film, the combination of a cylindrical member, means for rotating said cylindrical member at uniform speed, means for feeding the film upon said cylindrical member at one point and off therefrom at another point and causing it to adhere closely thereto without slippage between said points, and means, between which and the record film acoustically modulated energy is transferred, as the film moves past the same, coacting with the film when at a position on said cylindrical member intermediate said two first named points.

5. In phonographic apparatus in which the sound record is formed on a film, the combination of a cylindrical member, means for rotating said cylindrical member at uniform speed, means for feeding a record film onto said cylindrical member at one point and off therefrom at another point and causing the film to adhere closely to the cylindrical member without slippage between said points, said film record being arranged to overhang one side of the cylindrical member, and sound reproducing means positioned inwardly of the overhanging position of the film.

ALOYSIUS J. CAWLEY.

1290

Sept. 29, 1931. A. J. CAWLEY 1,825,441

SOUND RECORDING PROCESS AND APPARATUS

Filed Jan. 8, 1921

Fig. 1.

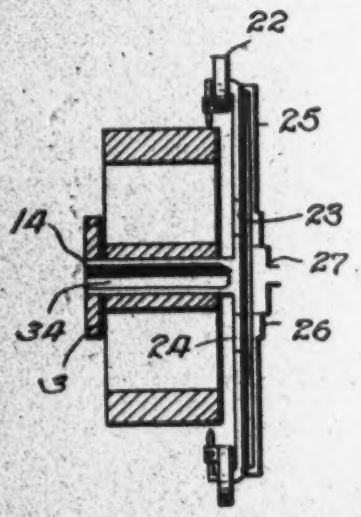


Fig. 2.

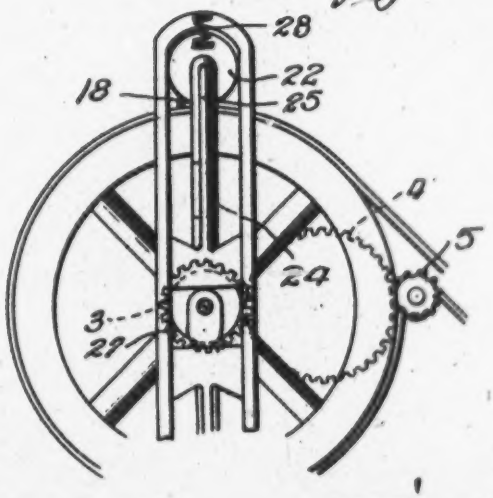


Fig. 3.

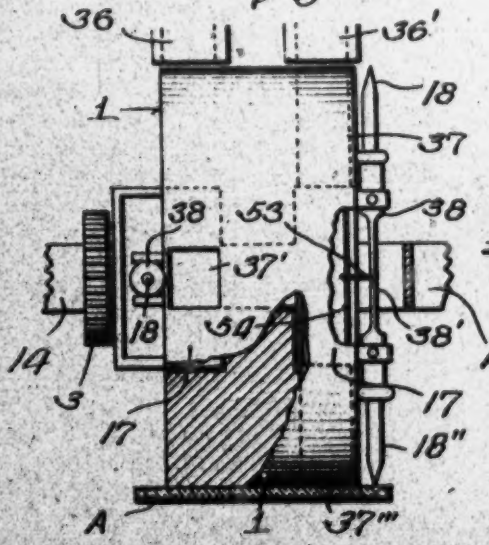


Fig. 4.

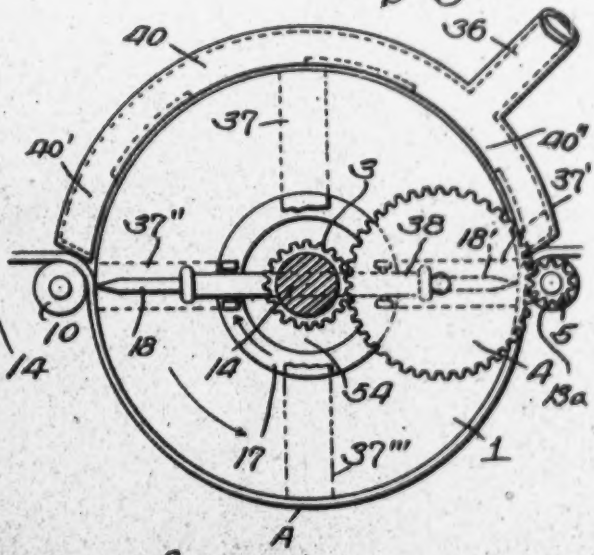
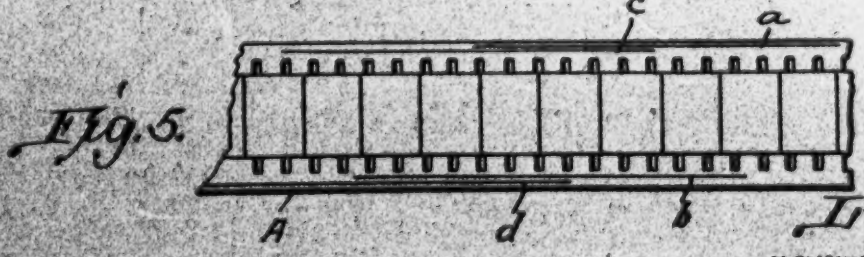


Fig. 5.



Inventor:

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by W. H. Grover

Patented Sept. 29, 1931

1291

1,825,441

UNITED STATES PATENT OFFICE

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SOUND RECORDING PROCESS AND APPARATUS

Application filed January 8, 1921. Serial No. 435,986.

The invention relates generally to the method of producing sound records on motion picture films, so that sound and picture records may be synchronously reproduced, although it is not necessarily limited to this field.

More particularly, the invention is concerned with the recording of sound on a film at a recording speed that is much in excess of the speed of the film. An arrangement is provided whereby a recorder is in contact with a film while moving in the opposite direction thereto. The recording speed is thus equal to the sum of the speeds of the recorder and film.

A plurality of recorders are employed. These make contact alternately with separate portions of the film. The recorders are placed radially at fixed intervals and one makes contact with a record surface of a given length, while the film has passed through but a fraction of this length. The other recorder is then in a position to make contact with an equivalent length juxtaposed thereto, or opposite to, that traversed by the first.

Arrangements are described whereby any desired sound recording speed may be obtained without any increase in the speed of the film by simply increasing the number and speed of the recording units.

The invention is perfectly adaptable to the standard motion picture film as it exists in practice at present, and is concerned with placing sound records on the margin or margins of such a film. The records are obviously of an intermittent character. This is readily feasible, particularly if mechanical sound grooves are used, as there is room for a very large number of such records on such margins. The records may be placed on one margin only, or may be distributed on both margins, as hereinafter described.

As the sound records are intended to be

It will be noted that there are no abrupt changes in the direction of the moving parts. All parts move in a uniform manner, and the apparatus as a whole is very simple. It is to be especially noted that, although the recording speed is rather high, neither the film carrier nor the recorders move at this speed, the high speed mentioned being due to the relative motion of recorder and film. This means that considerable wear is saved in the apparatus.

One can readily see that by employing a suitable number of recorders moving at a proper speed, that photographic sound recording processes requiring a speed of six feet per second may be utilized so that they may be placed on a film that is moving at the standard motion picture speed of one foot per second.

For a more complete understanding of the invention reference is to be had to the following description and claims taken in connection with the accompanying drawings, in which like characters of reference denote corresponding parts in all the views, and in which,

Figure 1 is a plan view of a device employing mechanical recording whereby the non-functioning recorder is raised from the film surface at the proper time.

Figure 2 is a side view of the mechanical recording arrangement shown in Figure 1.

Figure 3 is an elevational view, partly in cross-section, of another embodiment of the invention. This consists of two concentrically revolving sound recorders adapted to coact with circumferential valves.

Figure 4 is a side elevational view of the device shown in Figure 3.

Figure 5 is a plan view of a motion picture film having a plurality of high speed sound record grooves on its margin.

If it is desired to record or reproduce without the use of electricity, recourse may be had to the device illustrated in

Filed Jan. 8, 1921

Fig. 1.

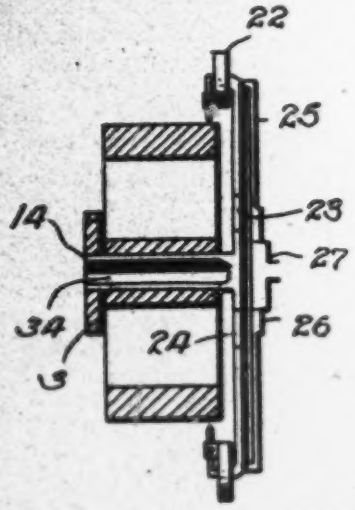


Fig. 2.

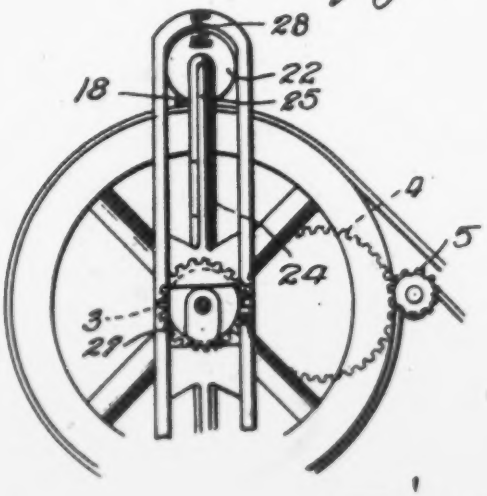


Fig. 3.

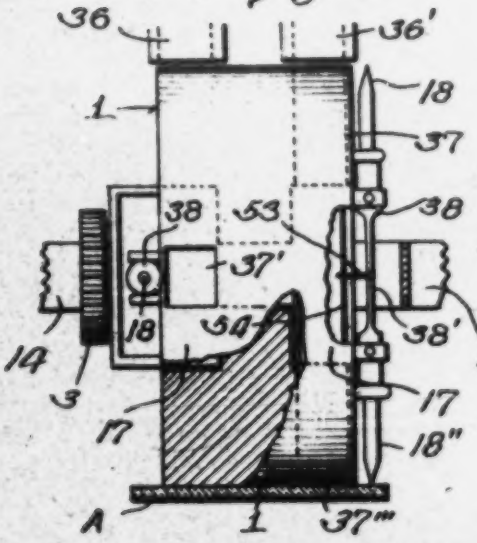


Fig. 4.

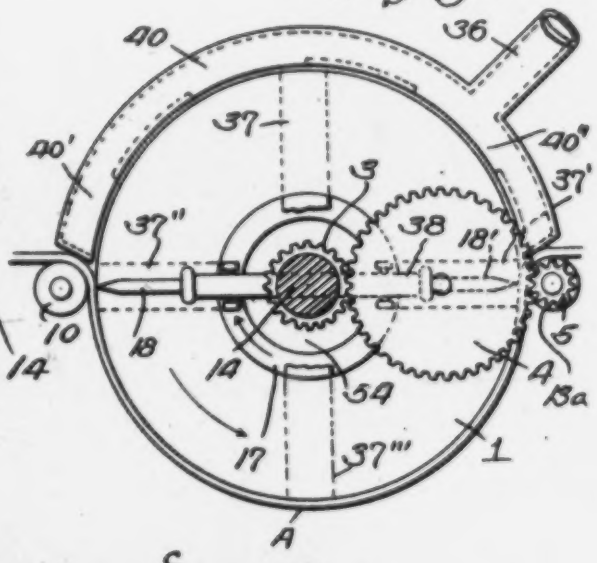
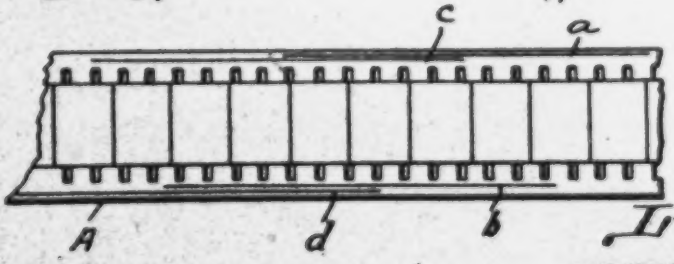


Fig. 5.



Inventor:
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UNITED STATES PATENT OFFICE

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SOUND RECORDING PROCESS AND APPARATUS

Application filed January 8, 1921. Serial No. 435,984.

The invention relates generally to the method of producing sound records on motion picture films, so that sound and picture records may be synchronously reproduced, although it is not necessarily limited to this field.

More particularly, the invention is concerned with the recording of sound on a film at a recording speed that is much in excess of the speed of the film. An arrangement is provided whereby a recorder is in contact with a film while moving in the opposite direction thereto. The recording speed is thus equal to the sum of the speeds of the recorder and film.

A plurality of recorders are employed. These make contact alternately with separate portions of the film. The recorders are placed radially at fixed intervals and one makes contact with a record surface of a given length, while the film has passed through but a fraction of this length. The other recorder is then in a position to make contact with an equivalent length juxtaposed thereto, or opposite to, that traversed by the first.

Arrangements are described whereby any desired sound recording speed may be obtained without any increase in the speed of the film by simply increasing the number and speed of the recording units.

The invention is perfectly adaptable to the standard motion picture film as it exists in practice at present, and is concerned with placing sound records on the margin or margins of such a film. The records are obviously of an intermittent character. This is readily feasible, particularly if mechanical sound grooves are used, as there is room for a very large number of such records on such margins. The records may be placed on one margin only, or may be distributed on both margins, as hereinafter described.

As the sound records are intended to be placed on the margins of the film, there is no interference of picture and sound record as would be the case, if for instance, the latter were placed across the reverse face of the film, as in such case, they would be projected upon the picture screen.

It will be noted that there are no abrupt changes in the direction of the moving parts. All parts move in a uniform manner, and the apparatus as a whole is very simple. It is to be especially noted that, although the recording speed is rather high, neither the film carrier nor the recorders move at this speed, the high speed mentioned being due to the relative motion of recorder and film. This means that considerable wear is saved in the apparatus.

One can readily see that by employing a suitable number of recorders moving at a proper speed, that photographic sound recording processes requiring a speed of six feet per second may be utilized so that they may be placed on a film that is moving at the standard motion picture speed of one foot per second.

For a more complete understanding of the invention reference is to be had to the following description and claims taken in connection with the accompanying drawings, in which like characters of reference denote corresponding parts in all the views, and in which,

Figure 1 is a plan view of a device employing mechanical recording whereby the non-functioning recorder is raised from the film surface at the proper time.

Figure 2 is a side view of the mechanical recording arrangement shown in Figure 1.

Figure 3 is an elevational view, partly in cross-section, of another embodiment of the invention. This consists of two concentrically revolving sound recorders adapted to coact with circumferential valves.

Figure 4 is a side elevational view of the device shown in Figure 3.

Figure 5 is a plan view of a motion picture film having a plurality of high speed sound record grooves on its margin.

If it is desired to record or reproduce without the use of electricity, recourse may be had to the device illustrated in Figures 1 and 2. Here the film is wound upon the revolving film carrier 1. The shaft 14 is made hollow. The recorders 22 connect with the hollow shaft by means of the hollow radial members 23, having the flexible ele-

ment 24, which may be either a section of rubber tubing or the like; this is designed to permit the recorders 22 to be lifted in turn from the surface of the film, by operation of the connections 25 provided with the shoes 26 which coact with the stationary cam 27. The cam is stationary, while the arms revolve. Gear wheel 3 is attached to the shaft 14, which is provided with the passage 34. External connection is made by means of a swivel or other flexible joint, which permits turning, but is sufficiently sound tight. The action of the spring 28 holds the shoes 26 in firm contact with the cam 27. Wheel 13a moves the film and toothed gear wheel 3, while 4 and 5 move the radial members in the opposite direction as in Figure 4. It is to be understood that actual contact with the film is only made through part of the circumference of film carrier 1, namely the left half shown in Figure 2. The radial member lifts the recorder 22 completely away from the film surface when it reaches the right half of the circumference. This post is however, not necessary, as the film at that point has been raised from the surface of wheel 1. Wheel 1 is no longer beneath it, consequently it may be freely bent downwards by the recorder as the latter passes forwards. The radial member is shown at 29 in Figure 1. No trouble is occasioned by the ravelling and unravelling of the film at the point where it leaves or arrives at the rotating member. The exact contour of the cam is not implied in the drawing, as it may be made in many forms other than that shown at 27.

By making the rotating film carrier 1 of very large diameter, the styli would remain in contact with the film for a much longer period. Also the possibility of the commutation of the different reproducers being audibly detected by the audience would be minimised.

A type of sound recording employing centrally located sound boxes and circumferential valves is described in Figures 3 and 4. Figure 3 is a view of a device in which two concentrically revolving sound recorders are provided with two styli each, the latter being actuated by means of bars 38 and 38′, that possess greater flexibility towards their centres in one plane only, while being perfectly rigid in a plane that is at right angles to this. The styli bars carrying the styli 18 and 18′ do not vibrate in the plane of their recording motion, but may be readily vibrated in a plane at right angles to this, due to the stylus bar being flattened or thinned in the plane of motion of the bar. As shown that only one recorder is connected to the external circuit at a time. All reference numerals have the same meaning as heretofore, and in addition, 36 and 36′ represent two of the radial valves. 37, 37′ are passages through 1 connecting the recorders with the valves at the proper time. The special stylus bars are shown at 38 and 38′. These may also be jointed, if desired. The diaphragm 54 is connected to the stylus bar 38′ by link 53.

The styli and film carrier move in opposite directions as before described, the commutation being made by means of the radial valves 36 and 36′, which are movable over the surface in order that they can be disposed so as to permit but one recorder to record or reproduce its own record.

In Figure 4, which is a view of the left side of Figure 3, it will be noticed that passage 37′ is just ceasing to give the record from its sound box, while 37 has just started to give its record. The opposite ends of the passages have been closed by film A. Passage 37 is communicating with opening 40, which extends for a distance of one-twelfth of the circumference of wheel 1; therefore, its corresponding stylus 18″ (Figure 3) is about to sweep from 37″′, in the lower part of the circle, to wheel 10 during the same time that passage 37 traverses the opening 40. Although stylus 18′ in the right horizontal position will pass from wheel 13a to 37″′ during the same period, its sound will not be heard because passage 37″ will not reach the valve opening 40″ in the upper right quadrant of the circle until stylus 18′ has reached the position of 37″′ in the lower semicircle. It will thus be seen that the arc extending from the point 37″′ in the lower semicircle to wheel 10 is the portion of the film where the sound is recorded or reproduced, the film passing through one-third of this arc, while the stylus passes over its entire length in the opposite direction. The sum of the speeds is four times film speed. If desired, the wheel 13a may be placed at 37, but in such case the arc between those two points should be covered by the surface of the valve, as shown in the upper semicircle between the valve openings. This is to prevent the escape of sound to the external air. It will be noticed that film A, covers one end of passages 37′, 37″ and 37″′, while the passage 37 communicates with the openings in the valves, such as 40. Also, since the film is held perfectly tight by means of wheels 10 and 13a, it will act as a spring to hold the stylus and film in contact, and it may be unnecessary to provide

In fact, this may be very desirable, as then it would compensate for the partial opening produced as at 37 communicating with 40. In this way, the two passages, such as 37 and 37′ in Figure 4 would reproduce in synchronism until 37 had achieved a full, open communication with 40, at which time 37′ would be completely cut off from its corresponding opening 40′. There will thus be a fusing together of the separate records, which will act to disguise the disconnected character of those elements and give the illusion of a single continuous record. Obviously there will always be the same area of sound passage communicating with the valve openings; when one is three quarters open, the other is one-quarter open, and so on. When one attains its full opening, the other is closed. One goes from zero to maximum during the same time that the other goes from maximum to zero. This feature will occupy the same position in fusing the separate elements into one as the persistence of vision of the optic nerve occupies in fusing the separate pictures of a motion picture film.

As shown in Fig. 3, the styli in this construction for producing a quadruple sound record are spaced at different distances from the edge of the cylinder so as to secure the desired or necessary separation of the grooves on the margin of the film.

The line *a* represents the record impressed by one stylus, and *b*, *c*, and *d* that impressed by the others during one revolution of stylus 18. Obviously, the stylus corresponding to groove *a* has again arrived at the end of its groove, and is ready to further extend it to the left. The other styli will in turn do likewise. On a complete film, therefore, there will be four continuous, parallel grooves through its length. Though a number of grooves may be used, still, emphasis is placed on two, giving a recording speed of two feet per second.

By varying the relative diameters of wheels 3, 4 and 5, any desired recording speed may be obtained, while film speed remains normal. The invention includes all such possible adjustments; moreover, it is not limited to any particular arc of contact between film and stylus; it may be a semi-circle.

As the invention is very flexible in principle, it is not limited to any of the combinations or arrangements which are available for selection.

Each recorder contacts with the precise portion of the film as regards right or left throughout the length of the film. As the there is room for many such record grooves on the margin of a moving picture film, the invention offers a means of placing several such records there, and utilizing them to reproduce sounds. Moreover, by this means a recording speed is available that is in excess of that used in commercial sound recording.

It will be apparent to those skilled in the art that many of the elements herein described, or referred to, are applicable to other species of sound recording or reproducing apparatus or are of general utility in the art, such subject-matter being more specifically claimed in my divisional applications, Serial Nos. 393,071; 393,072 and 393,078 all filed September 16, 1929.

By the term "longitudinally magnified", hereinafter, I refer to a sound record whose longitudinal extent relative to its carrying medium has been increased beyond the extent normally occupied by a record of the same sound.

Having thus described my invention, I claim as new and desire to secure by Letters Patent,

1. The process of sound recording and reproducing, consisting in moving a film and styli in opposite directions, to obtain a recording speed that is greater than film speed, and permitting but one stylus to function at a time.

2. A combination, consisting of means for moving a film and contacting styli in opposite directions, to obtain a speed of recording which is greater than film speed, and means for permitting but one recorder to function at a time.

3. A combination consisting of a film carrier and radial arms bearing recorders; means for moving the film carrier and recorders in opposite directions, to obtain a recording speed greater than film speed; and means for lifting a non-functioning recorder from the film surface.

4. A combination consisting of a film carrier and radial members bearing recorders rigidly connected to a hollow shaft to support said members; means for moving the film carrier and recorders in opposite directions, to obtain a recording speed that is greater than film speed; and means for mechanically lifting a non-functioning recorder from the film surface.

5. A combination consisting of a film carrier and radial arms carrying sound tubes and recorders which function alternately, and a hollow shaft to form a sound passage and support said arms; means for moving the film carrier and recorders in opposite di-

to permit the recorders 22 to be lifted in turn from the surface of the film, by operation of the connections 25 provided with the shoes 26 which coact with the stationary cam 27. The cam is stationary, while the arms revolve. Gear wheel 3 is attached to the shaft 14, which is provided with the passage 34. External connection is made by means of a swivel or other flexible joint, which permits turning, but is sufficiently sound tight. The action of the spring 28 holds the shoes 26 in firm contact with the cam 27. Wheel 13*a* moves the film and toothed gear wheel 3, while 4 and 5 move the radial members in the opposite direction as in Figure 4. It is to be understood that actual contact with the film is only made through part of the circumference of film carrier 1, namely the left half shown in Figure 2. The radial member lifts the recorder 22 completely away from the film surface when it reaches the right half of the circumference. This part is however, not necessary, as the film at that point has been raised from the surface of wheel 1. Wheel 1 is no longer beneath it, consequently it may be freely bent downwards by the recorder as the latter passes forwards. The radial member is shown at 29 in Figure 1. No trouble is occasioned by the rewelling and unravelling of the film at the point where it leaves or arrives at the rotating member. The exact contour of the cam is not implied in the drawing, as it may be made in many forms other than that shown at 27.

By making the rotating film carrier 1 of very large diameter, the styli would remain in contact with the film for a much longer period. Also the possibility of the commutation of the different reproducers being audibly detected by the audience would be minimised.

A type of sound recording employing centrally located sound boxes and circumferential valves is described in Figures 3 and 4. Figure 3 is a view of a device in which two concentrically revolving sound recorders are provided with two styli each, the latter being attached by means of bars 38 and 38′, that possess greater flexibility towards their centers in one plane only, while being perfectly rigid in a plane that is at right angles to this. The stylus bars carrying the styli 18 and 18′ do not vibrate in the plane of their greatest flexibility, but may be readily vibrated in a plane at right angles to this, due to the fact that they are flattened or thinned in the plane of vibration of the bar. As shown in Figure 3 the stylus bars 38′ are at right angles to each other; this, however, is not necessary. The valves in the apparatus are placed at the surface of member 1; several may be arranged circumferentially as desired. The reference numerals have the same meaning as heretofore, and in addition, 36 and 36′ represent two of the radial valves. 37, 37′ are passages through 1 connecting the recorders with the valves at the proper time. The special stylus bars are shown at 38 and 38′. These may also be jointed, if desired. The diaphragm 54 is connected to the stylus bar 38′ by link 53.

The styli and film carrier move in opposite directions as before described, the commutation being made by means of the radial valves 36 and 36′, which are movable over the surface in order that they can be disposed so as to permit but one recorder to record or reproduce its own record.

In Figure 4, which is a view of the left side of Figure 3, it will be noticed that passage 37′ is just ceasing to give the record from its sound box, while 37 has just started to give its record. The opposite ends of the passages have been closed by film A. Passage 37 is communicating with opening 40, which extends for a distance of one-twelfth of the circumference of wheel 1; therefore, its corresponding stylus 18″ (Figure 3) is about to sweep from 37″′, in the lower part of the circle, to wheel 10 during the same time that passage 37 traverses the opening 40. Although stylus 18′ in the right horizontal position will pass from wheel 13*a* to 37″′ during the same period, its sound will not be heard because passage 37″ will not reach the valve opening 40″ in the upper right quadrant of the circle until stylus 18′ has reached the position of 37″′ in the lower semicircle. It will thus be seen that the arc extending from the point 37″′ in the lower semicircle to wheel 10 is the portion of the film where the sound is recorded or reproduced, the film passing through one-third of this arc, while the stylus passes over its entire length in the opposite direction. The sum of the speeds is four times film speed. If desired, the wheel 13*a* may be placed at 37, but in such case the arc between those two points should be covered by the surface of the valve, as shown in the upper semicircle between the valve openings. This is to prevent the escape of sound to the external air. It will be noticed that film A covers one end of passages 37′, 37″ and 37″′, while the passage 37 communicates with the openings in the valves, such as 40. Also, since the film is held perfectly tight by means of wheels 10 and 13*a*, it will act as a spring to hold the stylus and film in contact, and it may be unnecessary to provide springs, or the like on arms 38, etc., to hold the two in contact. There is no objection to the overlapping of records, as it only means that the two records reproduce the same sounds in synchronism for a short interval.

In fact, this may be very desirable, as then it would compensate for the partial opening produced as at 37 communicating with 40. In this way, the two passages, such as 37 and 37′ in Figure 4 would reproduce in synchronism until 37 had achieved a full, open communication with 40, at which time 37′ would be completely cut off from its corresponding opening 40′. There will thus be a fusing together of the separate records, which will act to disguise the disconnected character of those elements and give the illusion of a single continuous record. Obviously there will always be the same area of sound passage communicating with the valve openings; when one is three quarters open, the other is one-quarter open, and so on. When one attains its full opening, the other is closed. One goes from zero to maximum during the same time that the other goes from maximum to zero. This feature will occupy the same position in fusing the separate elements into one as the persistence of vision of the optic nerve occupies in fusing the separate pictures of a motion picture film.

As shown in Fig. 3, the styli in this construction for producing a quadruple sound record are spaced at different distances from the edge of the cylinder so as to secure the desired or necessary separation of the grooves on the margin of the film.

The line *a* represents the record impressed by one stylus, and *b*, *c*, and *d* that impressed by the others during one revolution of stylus 18. Obviously, the stylus corresponding to groove *a* has again arrived at the end of its groove, and is ready to further extend it to the left. The other styli will in turn do likewise. On a complete film, therefore, there will be four continuous, parallel grooves through its length. Though a number of grooves may be used, still, emphasis is placed on two, giving a recording speed of two feet per second.

By varying the relative diameters of wheels 3, 4 and 5, any desired recording speed may be obtained, while film speed remains normal. The invention includes all such possible adjustments; moreover, it is not limited to any particular arc of contact between film and stylus; it may be a semi-circle.

As the invention is very flexible in principle, it is not limited to any of the combinations or arrangements which are available for selection.

Each recorder contacts with the precise portion of the film as regards right or left throughout the length of the film. As the latter is held rigidly in position, the proper sound reproducer finds its corresponding groove with absolute precision.

Laterally undulating sound recording has been very successful commercially, and as there is room for many such record grooves on the margin of a moving picture film, the invention offers a means of placing several such records there, and utilizing them to reproduce sounds. Moreover, by this means a recording speed is available that is in excess of that used in commercial sound recording.

It will be apparent to those skilled in the art that many of the elements herein described, or referred to, are applicable to other species of sound recording or reproducing apparatus or are of general utility in the art, such subject-matter being more specifically claimed in my divisional applications, Serial Nos. 393,071, 393,072 and 393,073 all filed September 16, 1929.

By the term "longitudinally magnified", hereinafter, I refer to a sound record whose longitudinal extent relative to its carrying medium has been increased beyond the extent normally occupied by a record of the same sound.

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1. The process of sound recording and reproducing, consisting in moving a film and styli in opposite directions, to obtain a recording speed that is greater than film speed, and permitting but one stylus to function at a time.

2. A combination, consisting of means for moving a film and contacting styli in opposite directions, to obtain a speed of recording which is greater than film speed, and means for permitting but one recorder to function at a time.

3. A combination consisting of a film carrier and radial arms bearing recorders; means for moving the film carrier and recorders in opposite directions, to obtain a recording speed greater than film speed; and means for lifting a non-functioning recorder from the film surface.

4. A combination consisting of a film carrier and radial members bearing recorders rigidly connected to a hollow shaft to support said members; means for moving the film carrier and recorders in opposite directions, to obtain a recording speed that is greater than film speed; and means for mechanically lifting a non-functioning recorder from the film surface.

5. A combination consisting of a film carrier and radial arms carrying sound tubes and recorders which function alternately, and a hollow shaft to form a sound passage and support said arms; means for moving the film carrier and recorders in opposite directions, to obtain a recording speed that is greater than film speed; and mechanical means for lifting a non-functioning recorder from the film surface.

6. A combination consisting of a film car-

rier and radial arms carrying sound tubes and recorders which alternately function, and a hollow shaft to form a sound passage and rotate said arms; mechanical means for lifting a non-functioning recorder from the film surface; shoes and rods, stationary cams operating said shoes and rods; gearing for moving the film carrier and recorders in opposite directions to obtain a recording speed greater than film speed.

7. A combination consisting of a large wheel freely rotating on a hollow shaft having a film wound around its periphery, two hollow radial members rigidly attached to said hollow shaft and bearing sound recorders which contact alternately with said film, said hollow shaft and hollow radial members forming a sound passage from said recorders to external air; a gear wheel rigidly mounted on said shaft, a wheel coacting with said film, gear wheels coacting with said first gear wheel and said sprocket to cause said recorders and said film to move in opposite directions while in alternate contact with each other; mechanical means such as shoes and cams to alternately lift one of said recorders from said film.

8. A combination consisting of a hollow shaft rigidly attached to two rotatable, hollow, radial arms bearing sound recorders, said hollow shaft and hollow arms acting to convey sound vibrations to said sound recorders, said arms being provided with a flexible link to render said arms extensible; means consisting of rods, shoes and cams for lifting one recorder alternately; a wheel engaging with a film, a gear wheel rigidly attached to said shaft, gear wheels engaging therewith to convey motion in the opposite direction to said sprocket wheel engaging with said film; a large wheel mounted loosely on said shaft and having said film wound around its periphery, said recorders making contact alternately with said film while both said film and said recorders are moved in opposite directions.

9. A combination consisting of a hollow shaft attached to two extensible hollow radial arms bearing sound recorders, said shaft and arms constituting a sound wave conveying means to said recorders; means for alternately extending said radial arms; a wheel loosely though accurately mounted on said shaft and bearing a film on its periphery; a gear wheel rigidly attached to said shaft and engaging with means for moving said film in a direction opposite to said wheel.

10. A combination consisting of a shaft carrying radial members bearing sound recorders, said recorders alternately functioning, a film engaging with the periphery of said wheel and moving therewith; a gear wheel mounted upon said shaft and gear wheels engaging therewith and coacting with said film in order to move said recorders and film in opposite directions.

11. A moving picture film bearing a number of longitudinal discontinuous complementary synchronized sound records each being longitudinally magnified in the same ratio as the number of records.

12. A combination including a film carrier consisting of a large wheel and radial arms bearing recorders; means for moving the film carrier and recorders in opposite directions, to obtain a recording speed greater than film speed; and means for lifting a non-functioning recorder from the film surface.

ALOYSIUS J. CAWLEY.

and a hollow shaft to form a sound passage and rotate said arms; mechanical means for lifting a non-functioning recorder from the film surface; shoes and rods, stationary cams operating said shoes and rods; gearing for moving the film carrier and recorders in opposite directions to obtain a recording speed greater than film speed.

7. A combination consisting of a large wheel freely rotating on a hollow shaft having a film wound around its periphery, two hollow radial members rigidly attached to said hollow shaft and bearing sound recorders which contact alternately with said film, said hollow shaft and hollow radial members forming a sound passage from said recorders to external air; a gear wheel rigidly mounted on said shaft, a wheel coacting with said film, gear wheels coacting with said first gear wheel and said sprocket to cause said recorders and said film to move in opposite directions while in alternate contact with each other; mechanical means such as shoes and cams to alternately lift one of said recorders from said film.

8. A combination consisting of a hollow shaft rigidly attached to two rotatable, hollow, radial arms bearing sound recorders, said hollow shaft and hollow arms acting to convey sound vibrations to said sound recorders, said arms being provided with a flexible link to render said arms extensible; means consisting of rods, shoes and cams for lifting one recorder alternately; a wheel engaging with a film, a gear wheel rigidly attached to said shaft, gear wheels engaging therewith to convey motion in the opposite direction to said sprocket wheel engaging with said film; a large wheel mounted loosely on said shaft and having said film wound around its periphery, said recorders making contact alternately with said film while both said film and said recorders are moved in opposite directions.

9. A combination consisting of a hollow shaft attached to two extensible hollow radial arms bearing sound recorders, said shaft and arms constituting a sound wave conveying means to said recorders; means for alternately extending said radial arms; a wheel loosely though accurately mounted on said shaft and bearing a film on its periphery; a gear wheel rigidly attached to said shaft and engaging with means for moving said film in a direction opposite to said wheel.

10. A combination consisting of a shaft carrying radial members bearing sound recorders, a gear wheel attached to said shaft; a cam on said shaft coacting with rods and shoes on said radial members to alternately extend one of said radial members; a wheel mounted but not attached to said shaft, a wheel and moving [illegible] mounted upon said shaft and gear wheels engaging therewith and coacting with said film in order to move said recorders and film in opposite directions.

11. A moving picture film bearing a number of longitudinal discontinuous complementary synchronized sound records each being longitudinally magnified in the same ratio as the number of records.

12. A combination including a film carrier consisting of a large wheel and radial arms bearing recorders; means for moving the film carrier and recorders in opposite directions, to obtain a recording speed greater than film speed; and means for lifting a non-functioning recorder from the film surface.

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Sept. 20, 1932. A. J. CAWLEY 1,878,577

SOUND REPRODUCING MEANS

Original Filed Oct. 3, 1919

Fig.1.

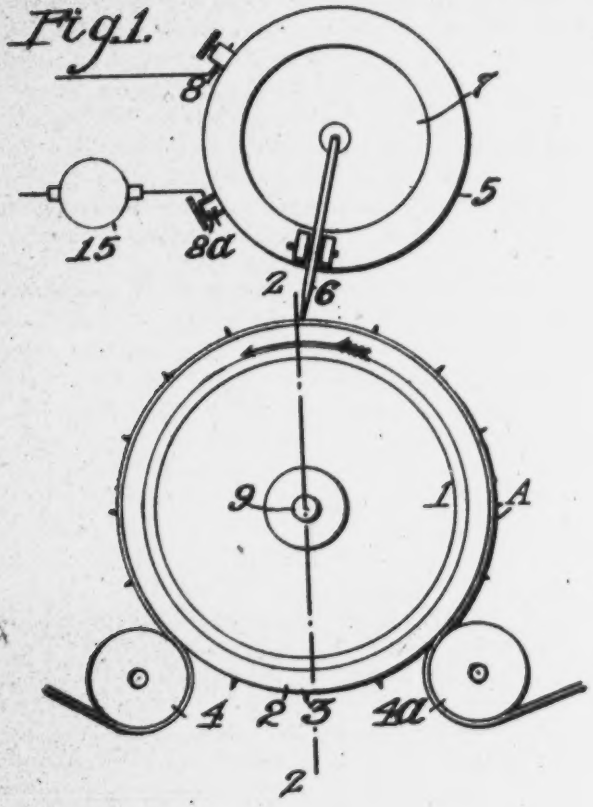


Fig.2.

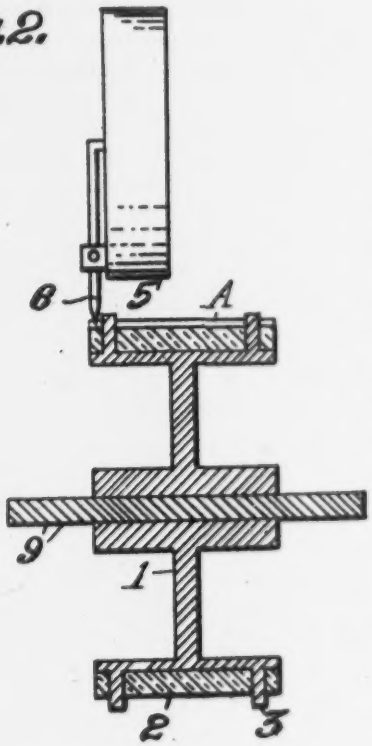


Fig.5.

Fig.4.

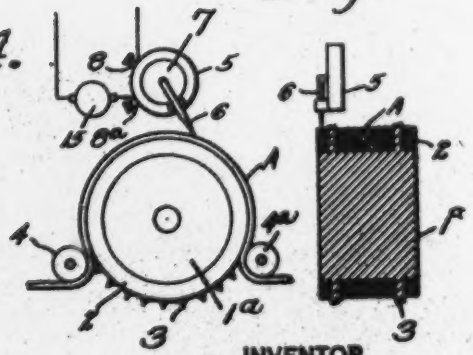
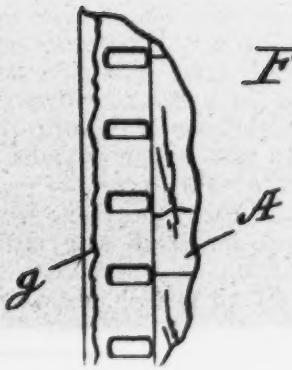


Fig.3.



INVENTOR

Alexander J. Cawley

Patented Sept. 20, 1932

1,878,577

UNITED STATES PATENT OFFICE

ALOYSIUS J. CAWLEY, OF PITTSTON, PENNSYLVANIA

SOUND REPRODUCING MEANS

Original applications filed October 3, 1919, Serial No. 328,299, and August 2, 1926, Serial No. 126,648. Divided and this application filed April 23, 1929. Serial No. 357,589.

This application is a division of my application, Serial Number 328,299, filed October 3, 1919, maturing in U. S. Patent No. 1,594,662, and application Serial Number 126,648, filed August 2, 1926, maturing in U. S. Patent No. 1,710,677, which covered a process of photographically magnifying sound records, preferably those produced on the margin of motion picture films, being a complete record of the movements and sounds of persons and objects. By the above process, the length of the sound record was not altered in the least.

Either from the laterally enlarged sound records, or from an unaltered original sound record groove, a linear ribbon-like patrix was made by passing the record through the interval between rolls while in contact with a suitable soft metal strip, and applying suitable pressure. The patrix could also be produced by electrochemical means. This patrix was cemented to the margin of the original negative motion picture film, thus forming a complete talking picture negative record, from which thousands of duplicates could be made in a very short time.

This talking picture negative was run through a combined motion picture printer and sound record molder, producing thereby any number of finished talking picture negatives, i. e., motion picture films bearing preferably on their margins, their own synchronous sound records.

In either imprinting a mechanical groove record on a motion picture film, thus forming its sound record, or in reproducing one of the complete talking picture positives, consisting of a photographic picture record and its corresponding synchronous sound record, as mentioned in the last paragraph, a special type of motion picture sprocket wheel, having a portion of its structure made of sound record backing material, was used. This constituted a veritable phonographic cylindrical record, which is capable of the most faithful reproduction of sounds.

trates certain embodiments of the invention, and wherein similar reference characters are employed to designate corresponding parts.

Figure 1 is an end view of the especially designed sprocket wheel which is intended to accomplish a more perfect recording and reproducing of sound records of the mechanical groove type on motion picture films.

Figure 2 is a cross-sectional view of the sprocket wheel on the line 2—2 of Fig. 1, the reproducer not being shown itself in cross section.

Figure 3 is a view of a motion picture film having a sound record groove on its margin corresponding to the sounds emitted by the objects photographed on the film.

Fig. 4 is an end view of a form of my invention.

Fig. 5 is a vertical cross section of the sprocket shown in Fig. 4.

In the recording and reproducing of sound records in practice, it is highly desirable that the film could be held perfectly rigid while moving at an absolutely uniform rate of speed. Figure 1 is an end view of a device, which may form a part of the camera or projector, and intended to accomplish this object. It illustrates a motion picture film A, as shown in Figure 1a of my U. S. Patent No. 1,594,662 mentioned above upon which has been impressed a sound record groove more clearly shown at g in Figure 3 of the synchronized sounds of the objects photographed on the film, passing through the projector and engaged by a stylus 6 which is attached to the diaphragm 7 of a microphone in order to impress the fluctuations corresponding to the sound record upon the electric current which traverses the microphone. The projector is not shown in its entirety but in accordance with the rules of the office, only the part of the projector with which the stylus cooperates, and which is here shown as the sprocket wheel adjacent the projector film gate. Obviously, a specially designed reproducer sprocket such as that illustrated in the ac-

Sept. 20, 1932. A. J. CAWLEY 1,878,577

SOUND REPRODUCING MEANS

Original Filed Oct. 3, 1919

Fig.1.

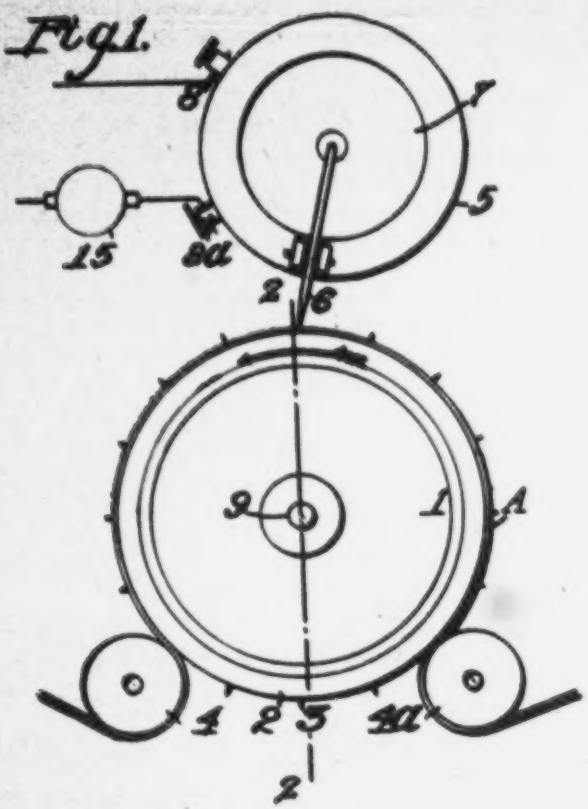


Fig.2.

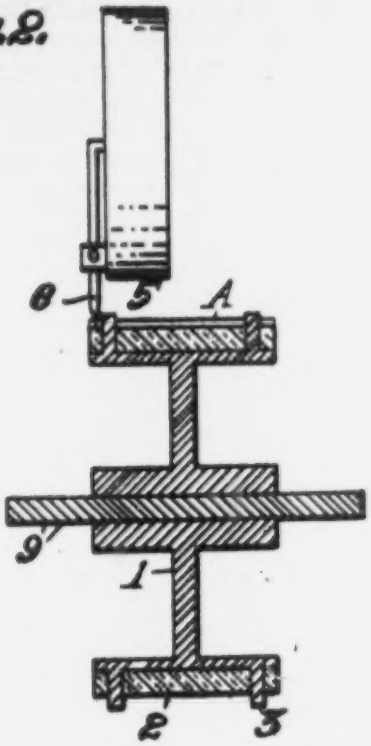


Fig.3.

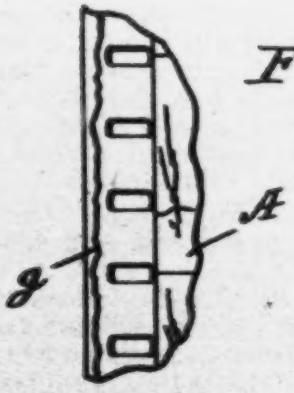


Fig.4.

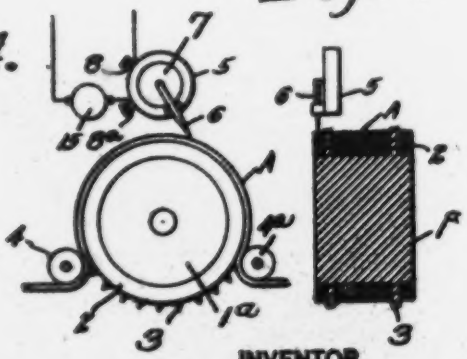


Fig.5.

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SOUND REPRODUCING MEANS

Original applications filed October 3, 1919, Serial No. 328,299, and August 2, 1926, Serial No. 126,648. Divided and this application filed April 23, 1929. Serial No. 357,229.

This application is a division of my application, Serial Number 328,299, filed October 3, 1919, maturing in U. S. Patent No. 1,594,662, and application Serial Number 126,648, filed August 2, 1926, maturing in U. S. Patent No. 1,710,677, which covered a process of photographically magnifying sound records, preferably those produced on the margin of motion picture films, being a complete record of the movements and sounds of persons and objects. By the above process, the length of the sound record was not altered in the least.

Either from the laterally enlarged sound records, or from an unaltered original sound record groove, a linear ribbon-like patrix was made by passing the record through the interval between rolls while in contact with a suitable soft metal strip, and applying suitable pressure. The patrix could also be produced by electrochemical means. This patrix was cemented to the margin of the original negative motion picture film, thus forming a complete talking picture negative record, from which thousands of duplicates could be made in a very short time.

This talking picture negative was run through a combined motion picture printer and sound record molder, producing thereby any number of finished talking picture negatives, i. e., motion picture films bearing preferably on their margins, their own synchronous sound records.

In either imprinting a mechanical groove record on a motion picture film, thus forming its sound record, or in reproducing one of the complete talking picture positives, consisting of a photographic picture record and its corresponding synchronous sound record, as mentioned in the last paragraph, a special type of motion picture sprocket wheel, having a portion of its structure made of sound record backing material, was used. This constituted a veritable phonographic cylindrical record, which is capable of the most faithful reproduction of sounds.

For a complete understanding of the invention, reference is to be had to the following description and claims taken in connection with the accompanying drawing, which illustrates certain embodiments of the invention, and wherein similar reference characters are employed to designate corresponding parts.

Figure 1 is an end view of the especially designed sprocket wheel which is intended to accomplish a more perfect recording and reproducing of sound records of the mechanical groove type on motion picture films.

Figure 2 is a cross-sectional view of the sprocket wheel on the line 2—2 of Fig. 1, the reproducer not being shown itself in cross section.

Figure 3 is a view of a motion picture film having a sound record groove on its margin corresponding to the sounds emitted by the objects photographed on the film.

Fig. 4 is an end view of a form of my invention.

Fig. 5 is a vertical cross section of the sprocket shown in Fig. 4.

In the recording and reproducing of sound records in practice, it is highly desirable that the film could be held perfectly rigid while moving at an absolutely uniform rate of speed. Figure 1 is an end view of a device, which may form a part of the camera or projector, and intended to accomplish this object. It illustrates a motion picture film A, as shown in Figure 1*a* of my U. S. Patent No. 1,594,662 mentioned above upon which has been impressed a sound record groove more clearly shown at *g* in Figure 3 of the synchronized sounds of the objects photographed on the film, passing through the projector and engaged by a stylus 6 which is attached to the diaphragm 7 of a microphone in order to impress the fluctuations corresponding to the sound record upon the electric current which traverses the microphone. The projector is not shown in its entirety but in accordance with the rules of the office, only the part of the projector with which the stylus cooperates, and which is here shown as the sprocket wheel adjacent the projector film gate. Obviously, a specially designed reproducer sprocket such as that illustrated in the accompanying drawing may be inserted at any part of the projector mechanism desired. This sprocket wheel is mounted on shaft 9 of the projector. The positive film A is held

in firm contact with this sprocket wheel 1, 1a, which is provided with a resilient ring 2. This may be made of hard rubber, which in turn may be coated with a rubber paint on its surface. It may be also made of any phonographic record backing material, or it may be made of any of the following substances: ebonite, wax, shellac, paper, or earthy composition.

Two rings extend upward from the steel body of the sprocket wheel through this ring or cushion, to form a base for the sprocket teeth. When the film is passed around this wheel and its perforations properly engaged with the sprocket teeth, the whole constitutes almost the exact equivalent of a cylindrical phonographic record on is mandrel. As it is well known to those skilled in the art and to the public in general, cylindrical phonograph records have been made and sold extensively to the public having an outside diameter of five inches and an inside diameter of four and one-half inches. Therefore, the wheel illustrated in the drawing may have, for instance, in one embodiment of the invention, an outside diameter of five inches. Similarly, the solid steel body of the wheel shown in the drawing and corresponding to the mandrel of a phonograph, will consist of a solid cylinder of steel four and one-half inches in diameter. This solid, cylindrical mass of metal will have a weight of about seven pounds, which will develop very great momentum when the wheel rotates, and this weight is in addition to that of the cylinder of phonograph record backing material corresponding to a five inch phonograph record, which forms the periphery of the wheel. Moreover, this cylindrical portion alone of the wheel corresponding to a large cylindrical phonograph record, has considerable weight or mass and consequent speed governing properties. The solid steel body of the wheel differs from the ordinary phonograph mandrel in being made solid, and in this respect the wheel is almost, but still not the exact equivalent of a cylindrical phonograph record on its mandrel. However, the disclosure is not by any means limited to this embodiment. The drawing also shows another embodiment in which this wheel with the otherwise solid cylindrical mass fashioned in the form of a fly wheel, which still has very considerable mass or weight. Thus the unsatisfactory reproduction from the frail film alone is done away with. The stylus, shown at 6, and the reproducer, which is shown as a microphone 7, are contained in the sound box 5. The electric power is shown as being supplied by 15, which may be a direct current dynamo, or may be included in the circuit which contains vacuum tube amplifying circuits, in order to increase the sound intensity. The contact rolls 4 and 4a hold the film in contact with ring 2. This type of sprocket wheel is intended for either recording or reproducing of sounds.

It is well known to those skilled in the art that a cylindrical phonograph record possesses sufficient mass to develop when in motion the requisite momentum to move the record surface with speed uniformity, and it is also very well known to those skilled in the art that this mass is supplied almost entirely by the phonographic backing material. Therefore, the ring 2 alone of the wheel possesses sufficient mass and developable momentum to cause the film to move with speed uniformity. However, the solid steel body is added to furnish additional mass or weight and consequent developable momentum. A wheel made in the proportions illustrated in Figure 1, which is to be taken merely as one embodiment of the invention, will possess a weight in excess of that of the usual fly wheel used on certain motion picture machines. However, the proportions of the large, solid metal wheel illustrated in my U. S. Patent No. 1,710,677 referred to above, or of that shown in the original drawing (of which Figures 4 and 5 are facsimilies) involve a mass much in excess of that shown in the wheel of Figure 1. Consequently, as a patent drawing is not a working drawing, the mere statement alone that the large steel wheel with its film constitutes almost the exact equivalent of a cylindrical phonograph record on its mandrel is sufficient to cover any degree of mass.

Having described my invention, I claim as new and desire to secure by Letters Patent,

1. A motion picture sprocket wheel, which is provided with a peripheral ring, a motion picture film bearing a sound record in firm contact with said ring, sound translating means coacting with said sound record at the area of contact with said wheel in order that the momentum of said wheel shall move said film with speed uniformity and resulting perfect sound translation.

2. In combination: a large motion picture wheel of considerable mass and a motion picture film of inconsiderable mass bearing a sound record, contact rolls holding said motion picture film in firm contact with said wheel, and a sound recording or reproducing means coacting with said sound record carried on said film at the point where said film is in contact with said wheel, in order that said wheel shall move said film with a

adherent surface a flexible sound record film in firm contact with said wheel over an arc of its circumference.

4. A wheel possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity, a flexible sound record film in firm contact with said wheel over an arc of its circumference, constituting the equivalent of a cylindrical sound record whose surface is continually changing, sound recording or reproducing means coacting with said record film to obtain faithful sound records.

5. A wheel possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity, engaging with and moving a flexible sound record film, means for engaging and disengaging said film with said wheel respectively before and after said film coacts with a sound recorder or reproducer.

6. A large wheel possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity, a flexible longitudinal sound record film engaging with said wheel causing said film to be moved at an absolutely uniform rate of speed and a sound reproducer coacting with said sound record film at a point on the area of engagement with said wheel in order to obtain perfect sound reproduction.

7. A film moving means possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity, a flexible sound record film in firm contact with said wheel over an arc of its circumference, constituting the equivalent of a cylindrical sound record having a continually changing surface, sound reproducing or recording means coacting with said film.

8. A motion picture sprocket wheel possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity provided with an adherent, resilient ring, a flexible sound record film in firm contact with said wheel over an arc of its circumference, sound reproducing means coacting with said film at a point on said arc.

9. A film moving means provided with teeth and possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity, a sound record film in firm contact with said wheel over an arc of its circumference, sound recording or reproducing means coacting with said film.

10. A film moving means provided with film engaging means and possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity a flexible sound record film in firm contact with said wheel over an arc of its circumference, and sound recording or sound reproducing

enough mass to produce, when in motion sufficient momentum to insure speed uniformity, means for retaining in close engagement a sound record film over an arc of said moving means, and sound recording or sound reproducing means coacting with said film at a portion located on said arc.

12. A cylinder possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity, a sound record film in cooperative relation with said cylinder means for retaining in close engagement said sound record film over an arc of said cylinder, sound recording or reproducing means coacting with said film at a portion of said film located on said arc to obtain most faithful sound recording or reproducing.

13. A motion picture sprocket wheel provided with a metal body possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity, a motion picture film bearing a sound record engaging with said wheel over an arc of its surface to be moved at absolute speed uniformity, sound recording or reproducing means coacting with said film sound record at a portion of said arc.

14. A film moving means provided with a rim of phonographic record backing material, said rim possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity, a motion picture film bearing a sound record which engages with said rim over an arc of its surface, sound recording or reproducing means coacting with said film sound record at a portion of said arc.

15. A cylindrical film moving means having an adherent surface possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity, a film bearing a sound record engaging with said moving means over an arc of its circumference, contact rolls holding said film in contact with said moving means, sound recording or reproducing means engaging with said film at a portion of said arc.

16. A cylinder of phonographic record material provided with a metal body possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity, a film bearing a sound record engaging with said cylinder for an arc of its circumference, means for feeding said film being removed to said cylinder before said arc and means for removing said film after traversing said arc, sound recording or reproducing means coacting with said film at a point on said arc ensuring sound recording and reproducing of great fidelity.

17. The method of translating sound or similar vibrations to or from a film record

in firm contact with this sprocket wheel 1, 1a, which is provided with a resilient ring 2. This may be made of hard rubber, which in turn may be coated with a rubber paint on its surface. It may be also made of any phonographic record backing material, or it may be made of any of the following substances: ebonite, wax, shellac, paper, or earthy composition.

Two rings extend upward from the steel body of the sprocket wheel through this ring or cushion, to form a base for the sprocket teeth. When the film is passed around this wheel and its perforations properly engaged with the sprocket teeth, the whole constitutes almost the exact equivalent of a cylindrical phonographic record on is mandrel. As it is well known to those skilled in the art and to the public in general, cylindrical phonograph records have been made and sold extensively to the public having an outside diameter of five inches and an inside diameter of four and one-half inches. Therefore, the wheel illustrated in the drawing may have, for instance, in one embodiment of the invention, an outside diameter of five inches. Similarly, the solid steel body of the wheel shown in the drawing and corresponding to the mandrel of a phonograph, will consist of a solid cylinder of steel four and one-half inches in diameter. This solid, cylindrical mass of metal will have a weight of about seven pounds, which will develop very great momentum when the wheel rotates, and this weight is in addition to that of the cylinder of phonograph record backing material corresponding to a five inch phonograph record, which forms the periphery of the wheel. Moreover, this cylindrical portion alone of the wheel corresponding to a large cylindrical phonograph record, has considerable weight or mass and consequent speed governing properties. The solid steel body of the wheel differs from the ordinary phonograph mandrel in being made solid, and in this respect the wheel is almost, but still not the exact equivalent of a cylindrical phonograph record on its mandrel. However, the disclosure is not by any means limited to this embodiment. The drawing also shows another embodiment in which this wheel with the otherwise solid cylindrical mass fashioned in the form of a fly wheel, which still has very considerable mass or weight. Thus the unsatisfactory reproduction from the frail film alone is done away with. The stylus, shown at 6, and the reproducer, which is shown as a microphone 7, are contained in the sound box 5. The electric power is shown as being supplied by 15, which may be a direct current dynamo, or storage battery, as it is desired to obtain a loud, powerful reproduction. The wires from binding posts 8 and 8a lead to a loud speaking telephone receiver located near or behind the picture screen. An induction coil may be included in the circuit which contains vacuum tube amplifying circuits, in order to increase the sound intensity. The contact rolls 4 and 4a hold the film in contact with ring 2. This type of sprocket wheel is intended for either recording or reproducing of sounds.

It is well known to those skilled in the art that a cylindrical phonograph record possesses sufficient mass to develop when in motion the requisite momentum to move the record surface with speed uniformity, and it is also very well known to those skilled in the art that this mass is supplied almost entirely by the phonographic backing material. Therefore, the ring 2 alone of the wheel possesses sufficient mass and developable momentum to cause the film to move with speed uniformity. However, the solid steel body is added to furnish additional mass or weight and consequent developable momentum. A wheel made in the proportions illustrated in Figure 1, which is to be taken merely as one embodiment of the invention, will possess a weight in excess of that of the usual fly wheel used on certain motion picture machines. However, the proportions of the large, solid metal wheel illustrated in my U. S. Patent No. 1,710,677 referred to above, or of that shown in the original drawing (of which Figures 4 and 5 are facsimilies) involve a mass much in excess of that shown in the wheel of Figure 1. Consequently, as a patent drawing is not a working drawing, the mere statement alone that the large steel wheel with its film constitutes almost the exact equivalent of a cylindrical phonograph record on its mandrel is sufficient to cover any degree of mass.

Having described my invention, I claim as new and desire to secure by Letters Patent,

1. A motion picture sprocket wheel, which is provided with a peripheral ring, a motion picture film bearing a sound record in firm contact with said ring, sound translating means coacting with said sound record at the area of contact with said wheel in order that the momentum of said wheel shall move said film with speed uniformity and resulting perfect sound translation.

2. In combination: a large motion picture wheel of considerable mass and a motion picture film of inconsiderable mass bearing a sound record, contact rolls holding said motion picture film in firm contact with said wheel, and a sound recording or reproducing means coacting with said sound record carried on said film at the point where said film is in contact with said wheel, in order that said wheel shall move said film with a uniform motion resulting in great fidelity in sound recording or reproducing.

3. A wheel possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity, provided with an

film in firm contact with said wheel over an arc of its circumference.

4. A wheel possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity, a flexible sound record film in firm contact with said wheel over an arc of its circumference, constituting the equivalent of a cylindrical sound record whose surface is continually changing, sound recording or reproducing means coacting with said record film to obtain faithful sound records.

5. A wheel possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity, engaging with and moving a flexible sound record film, means for engaging and disengaging said film with said wheel respectively before and after said film coacts with a sound recorder or reproducer.

6. A large wheel possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity, a flexible longitudinal sound record film engaging with said wheel causing said film to be moved at an absolutely uniform rate of speed and a sound reproducer coacting with said sound record film at a point on the area of engagement with said wheel in order to obtain perfect sound reproduction.

7. A film moving means possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity, a flexible sound record film in firm contact with said wheel over an arc of its circumference, constituting the equivalent of a cylindrical sound record having a continually changing surface, sound reproducing or recording means coacting with said film.

8. A motion picture sprocket wheel possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity provided with an adherent, resilient ring, a flexible sound record film in firm contact with said wheel over an arc of its circumference, sound reproducing means coacting with said film at a point on said arc.

9. A film moving means provided with teeth and possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity, a sound record film in firm contact with said wheel over an arc of its circumference, sound recording or reproducing means coacting with said film.

10. A film moving means provided with film engaging means and possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity a flexible sound record film in firm contact with said wheel over an arc of its circumference, and sound recording or sound reproducing means coacting with said film at a portion located on said arc.

11. A large film moving means possessing enough momentum to [illegible] means for retaining in close engagement a sound record film over an arc of said moving means, and sound recording or sound reproducing means coacting with said film at a portion located on said arc.

12. A cylinder possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity, a sound record film in cooperative relation with said cylinder means for retaining in close engagement said sound record film over an arc of said cylinder, sound recording or reproducing means coacting with said film at a portion of said film located on said arc to obtain most faithful sound recording or reproducing.

13. A motion picture sprocket wheel provided with a metal body possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity, a motion picture film bearing a sound record engaging with said wheel over an arc of its surface to be moved at absolute speed uniformity, sound recording or reproducing means coacting with said film sound record at a portion of said arc.

14. A film moving means provided with a rim of phonographic record backing material, said rim possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity, a motion picture film bearing a sound record which engages with said rim over an arc of its surface, sound recording or reproducing means coacting with said film sound record at a portion of said arc.

15. A cylindrical film moving means having an adherent surface possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity, a film bearing a sound record engaging with said moving means over an arc of its circumference, contact rolls holding said film in contact with said moving means, sound recording or reproducing means engaging with said film at a portion of said arc.

16. A cylinder of phonographic record material provided with a metal body possessing enough mass to produce, when in motion sufficient momentum to insure speed uniformity, a film bearing a sound record engaging with said cylinder for an arc of its circumference, means for feeding said film being removed to said cylinder before said arc and means for removing said film after traversing said arc, sound recording or reproducing means coacting with said film at a point on said arc ensuring sound recording and reproducing of great fidelity.

17. The method of translating sound or similar vibrations to or from a film record by the use of sound recording or reproducing means, which comprises flexing the film arcuately longitudinally at the point of trans-

lation and rapidly and uniformly moving the film in a circumferential direction past said point.

18. The method of translating sound or similar vibrations to or from a film record by sound recording or reproducing means, comprising rapidly advancing the film past the point of translation, and subjecting the motion of the film in passing said point, to the control of inertia means to eliminate irregularities in the movement of the film.

19. A large wheel of considerable mass developing sufficient momentum, when in motion, to produce speed uniformity, a film of inconsiderable mass bearing a sound record engaging with an arc of the circumference of said wheel, means for accurately and fixedly holding said film in contact with said wheel at said arc, sound recording or reproducing means coacting with said film at a point on said arc, to record sound upon or to reproduce sound from said film while being moved by said wheel at a uniform rate of speed, resulting in sound recording or reproducing of great fidelity.

20. A large wheel, a film bearing a sound record engaging with an arc of the circumference of said wheel, means for accurately and fixedly holding said film in contact with said wheel at said arc, sound recording or reproducing means coacting with said film at a point on said arc to record sound upon or reproduce sound from said film record, while said film is held fixedly at said arc.

21. In combination, a flexible, longitudinal member bearing a sound record, a rotating element having considerable mass and an adherent surface firmly and fixedly engaging with said member along an arc of its circumference, sound translating means cooperating with said sound record at a point on said arc.

22. In combination, a flexible, longitudinal member bearing a sound record, a rotating element having considerable mass and an adherent surface firmly and fixedly engaging with said member along an arc of its circumference, sound translating means cooperating with said sound record at a point on said arc, and means for causing said member to adhere closely to said rotating element along said arc.

23. In phonograph apparatus in which the record is formed on an elongated carrier of inconsiderable mass, the combination of means for supporting and progressing said elongated member from one point to another point, and past an intermediate point at which the record is made on the member in recording or from which the record is taken from the member in reproducing, in-

speed under control of the mass of said rotating element.

24. In phonograph apparatus in which the sound record is formed on an elongated carrier of inconsiderable mass, the combination of a rotating element of considerable mass, means for rotating said element at uniform speed under the control of the mass of said rotating element, means for feeding the carrier upon said rotating element at one point and off therefrom at another point and causing it to adhere closely thereto without slippage between said points, and means, between which and the record acoustically modulated energy is transferred, as the carrier moves past the same, coacting with the carrier when at a position on said rotating element intermediate said two first named points.

25. In phonograph apparatus in which the sound record is formed on an elongated ribbon of inconsiderable mass, having feeding perforations therein, the combination of means for supporting and progressing the record ribbon from one point to another point and past an intermediate point at which the record is made on the ribbon in recording or from which the record is taken from the ribbon in reproducing, including a toothed rotating element of considerable mass over a portion of which the ribbon passes adjacent to said intermediate point, the teeth of said rotating element engaging the perforations of said ribbon, and means for rotating said cylinder at uniform speed under the control of the mass of said rotating element.

26. In phonographic apparatus in which the sound record is formed on an elongated ribbon of inconsiderable mass, having feeding perforations therein, the combination of means for supporting and progressing the record ribbon from one point to another point and past an intermediate point at which the record is made on the ribbon in recording or from which the record is taken from the ribbon in reproducing, including a rotating element of considerable mass for supporting the record at said intermediate point, the mass of said rotating element causing uniform motion to be imparted to said rotating element, toothed means engaging the perforations of the ribbon for feeding the latter over said rotating element, and means contacting with the ribbon to prevent vibration thereof when said toothed means are engaging or disengaging with the perforations of the said ribbon.

27. In phonograph apparatus in which the sound record is formed on an elongated carrier of inconsiderable mass, the combination of means for supporting and progressing the

cluding a rotating element of considerable mass over a portion of the periphery of which the carrier passes adjacent to said intermediate point, said carrier progressing means operating to advance the carrier past said intermediate point at uniform speed under control of the mass of said rotating element.

28. In combination, a flexible, longitudinally movable moving picture and sound record film, rotatable mechanism having sufficient mass to maintain by its momentum a uniform rate of speed, said rotatable mechanism being operative with said film to advance the same, and sound translating means cooperative with said sound record film.

29. In combination, a flexible moving picture and sound record film, rotating mechanism having sufficient mass to maintain a uniform rate of speed, a surface of the rotating mass fixedly engaging said film along an arc of its circumference and sound translating means cooperative with said sound record at a point on said surface and means to rotate the mass of material.

30. Means for holding perfectly rigid and moving at an absolutely uniform rate of speed a longitudinal sound record, consisting of a large wheel provided with a metal body, a flexible sound record in firm engagement with said wheel over an arc of the circumference of said wheel, and a sound translating means in cooperative relation with said record at a point on said arc.

31. Means for holding perfectly rigid and moving at an absolutely uniform rate of speed a longitudinal sound record, consisting of a large wheel provided with a solid metal body, a flexible sound record in firm engagement with said wheel over an arc of the circumference of said wheel, and a sound translating means in cooperative relation with said record at a point on said arc.

32. Means for holding perfectly rigid and moving at an absolutely uniform rate of speed a longitudinal sound record, consisting of a large wheel provided with a metal body, a flexible sound record in firm engagement with said wheel over an arc of the circumference of said wheel, a sound translating means in cooperative relation with said record at a point on said arc and means for holding said film in firm engagement throughout said arc.

33. Means for holding perfectly rigid and moving at an absolutely uniform rate of speed a longitudinal sound record, consisting of a large wheel provided with a metal body and an adherent surface, a flexible sound record in firm engagement with said wheel over an arc of the circumference of said wheel and a sound translating means in cooperative relation with said record at a point on said arc.

34. Means for holding perfectly rigid and moving at an absolutely uniform rate of speed a talking motion picture film bearing a sound record, consisting of a large wheel provided with a metal body, a flexible sound record in firm engagement with said wheel over an arc of the circumference of said wheel and a sound translating means in cooperative relation with said record at a point on said arc.

35. Means for holding perfectly rigid and moving at an absolutely uniform rate of speed a talking motion picture film bearing a sound record, consisting of a large wheel provided with a metal body, a talking motion picture film in firm engagement with said wheel over an arc of the circumference of said wheel, said film bearing a sound record, and a sound translating means in cooperative relation with said record at a point on said arc.

36. Means for holding perfectly rigid and moving at an absolutely uniform rate of speed a talking motion picture film bearing a sound record, consisting of a large wheel provided with a solid metal body, a talking motion picture film in firm engagement with said wheel over an arc of the circumference of said wheel, and a sound translating means in cooperative relation with said record at a point on said arc.

37. Means for holding perfectly rigid and moving at an absolutely uniform rate of speed a talking motion picture film bearing a sound record, consisting of a large wheel provided with a metal body, a talking motion picture film in firm engagement with said wheel over an arc of the circumference of said wheel, sound translating means in cooperative relation with said record at a point on said arc, and means for holding said film in firm engagement with said wheel along said arc.

38. Means for holding perfectly rigid and moving at an absolutely uniform rate of speed a talking motion picture film bearing a sound record, consisting of a large metal wheel, a talking motion picture film in firm engagement with said wheel over an arc of the circumference of said wheel, and sound translating means in cooperative relation with said record at a point on said arc.

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lation and rapidly and uniformly moving the film in a circumferential direction past said point.

18. The method of translating sound or similar vibrations to or from a film record by sound recording or reproducing means, comprising rapidly advancing the film past the point of translation, and subjecting the motion of the film in passing said point, to the control of inertia means to eliminate irregularities in the movement of the film.

19. A large wheel of considerable mass developing sufficient momentum, when in motion, to produce speed uniformity, a film of inconsiderable mass bearing a sound record engaging with an arc of the circumference of said wheel, means for accurately and fixedly holding said film in contact with said wheel at said arc, sound recording or reproducing means coacting with said film at a point on said arc, to record sound upon or to reproduce sound from said film while being moved by said wheel at a uniform rate of speed, resulting in sound recording or reproducing of great fidelity.

20. A large wheel, a film bearing a sound record engaging with an arc of the circumference of said wheel, means for accurately and fixedly holding said film in contact with said wheel at said arc, sound recording or reproducing means coacting with said film at a point on said arc to record sound upon or reproduce sound from said film record, while said film is held fixedly at said arc.

21. In combination, a flexible, longitudinal member bearing a sound record, a rotating element having considerable mass and an adherent surface firmly and fixedly engaging with said member along an arc of its circumference, sound translating means cooperating with said sound record at a point on said arc.

22. In combination, a flexible, longitudinal member bearing a sound record, a rotating element having considerable mass and an adherent surface firmly and fixedly engaging with said member along an arc of its circumference, sound translating means cooperating with said sound record at a point on said arc, and means for causing said member to adhere closely to said rotating element along said arc.

23. In phonograph apparatus in which the record is formed on an elongated carrier of inconsiderable mass, the combination of means for supporting and progressing said elongated member from one point to another point, and past an intermediate point at which the record is made on the member in recording or from which the record is taken from the member in reproducing, including a rotating element of considerable mass over a portion of the periphery of which said member adjacent intermediate point, and means for rotating said cylinder at uniform speed under control of the mass of said rotating element.

24. In phonograph apparatus in which the sound record is formed on an elongated carrier of inconsiderable mass, the combination of a rotating element of considerable mass, means for rotating said element at uniform speed under the control of the mass of said rotating element, means for feeding the carrier upon said rotating element at one point and off therefrom at another point and causing it to adhere closely thereto without slippage between said points, and means, between which and the record acoustically modulated energy is transferred, as the carrier moves past the same, coacting with the carrier when at a position on said rotating element intermediate said two first named points.

25. In phonograph apparatus in which the sound record is formed on an elongated ribbon of inconsiderable mass, having feeding perforations therein, the combination of means for supporting and progressing the record ribbon from one point to another point and past an intermediate point at which the record is made on the ribbon in recording or from which the record is taken from the ribbon in reproducing, including a toothed rotating element of considerable mass over a portion of which the ribbon passes adjacent to said intermediate point, the teeth of said rotating element engaging the perforations of said ribbon, and means for rotating said cylinder at uniform speed under the control of the mass of said rotating element.

26. In phonographic apparatus in which the sound record is formed on an elongated ribbon of inconsiderable mass, having feeding perforations therein, the combination of means for supporting and progressing the record ribbon from one point to another point and past an intermediate point at which the record is made on the ribbon in recording or from which the record is taken from the ribbon in reproducing, including a rotating element of considerable mass for supporting the record at said intermediate point, the mass of said rotating element causing uniform motion to be imparted to said rotating element, toothed means engaging the perforations of the ribbon for feeding the latter over said rotating element, and means contacting with the ribbon to prevent vibration thereof when said toothed means are engaging or disengaging with the perforations of the said ribbon.

27. In phonograph apparatus in which the sound record is formed on an elongated carrier of inconsiderable mass, the combination of means for supporting and progressing the elongated carrier from one point to another point at which the record is made on the carrier in recording or from which the record is taken from the carrier in reproducing, in-

mass over a portion of the periphery of which the carrier passes adjacent to said intermediate point, said carrier progressing means operating to advance the carrier past said intermediate point at uniform speed under control of the mass of said rotating element.

28. In combination, a flexible, longitudinally movable moving picture and sound record film, rotatable mechanism having sufficient mass to maintain by its momentum a uniform rate of speed, said rotatable mechanism being operative with said film to advance the same, and sound translating means cooperative with said sound record film.

29. In combination, a flexible moving picture and sound record film, rotating mechanism having sufficient mass to maintain a uniform rate of speed, a surface of the rotating mass fixedly engaging said film along an arc of its circumference and sound translating means cooperative with said sound record at a point on said surface and means to rotate the mass of material.

30. Means for holding perfectly rigid and moving at an absolutely uniform rate of speed a longitudinal sound record, consisting of a large wheel provided with a metal body, a flexible sound record in firm engagement with said wheel over an arc of the circumference of said wheel, and a sound translating means in cooperative relation with said record at a point on said arc.

31. Means for holding perfectly rigid and moving at an absolutely uniform rate of speed a longitudinal sound record, consisting of a large wheel provided with a solid metal body, a flexible sound record in firm engagement with said wheel over an arc of the circumference of said wheel, and a sound translating means in cooperative relation with said record at a point on said arc.

32. Means for holding perfectly rigid and moving at an absolutely uniform rate of speed a longitudinal sound record, consisting of a large wheel provided with a metal body, a flexible sound record in firm engagement with said wheel over an arc of the circumference of said wheel, a sound translating means in cooperative relation with said record at a point on said arc and means for holding said film in firm engagement throughout said arc.

33. Means for holding perfectly rigid and moving at an absolutely uniform rate of speed a longitudinal sound record, consisting of a large wheel provided with a metal body and an adherent surface, a flexible sound record in firm engagement with said wheel over an arc of the circumference of said wheel and a sound translating means in cooperative relation with said record at a point on said arc.

34. Means for holding perfectly rigid and moving at an absolutely uniform rate of speed a longitudinal sound record, consisting of a large wheel provided with a resilient record in firm engagement with said wheel over an arc of the circumference of said wheel and a sound translating means in cooperative relation with said record at a point on said arc.

35. Means for holding perfectly rigid and moving at an absolutely uniform rate of speed a talking motion picture film bearing a sound record, consisting of a large wheel provided with a metal body, a talking motion picture film in firm engagement with said wheel over an arc of the circumference of said wheel, said film bearing a sound record, and a sound translating means in cooperative relation with said record at a point on said arc.

36. Means for holding perfectly rigid and moving at an absolutely uniform rate of speed a talking motion picture film bearing a sound record, consisting of a large wheel provided with a solid metal body, a talking motion picture film in firm engagement with said wheel over an arc of the circumference of said wheel, and a sound translating means in cooperative relation with said record at a point on said arc.

37. Means for holding perfectly rigid and moving at an absolutely uniform rate of speed a talking motion picture film bearing a sound record, consisting of a large wheel provided with a metal body, a talking motion picture film in firm engagement with said wheel over an arc of the circumference of said wheel, sound translating means in cooperative relation with said record at a point on said arc, and means for holding said film in firm engagement with said wheel along said arc.

38. Means for holding perfectly rigid and moving at an absolutely uniform rate of speed a talking motion picture film bearing a sound record, consisting of a large metal wheel, a talking motion picture film in firm engagement with said wheel over an arc of the circumference of said wheel, and sound translating means in cooperative relation with said record at a point on said arc.

Pittston, Pa., April 20, 1929.

ALOYSIUS J. CAWLEY.

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CERTIFICATE OF CORRECTION.

Patent No. 1,878,577. September 20, 1932.

ALOYSIUS J. CAWLEY.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, line 73, for "could" read "should"; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 28th day of February, A. D. 1933.

M. J. Moore,
Acting Commissioner of Patents.

(Seal)

1303

179-100. 2

[Fifth Edition.]

A.D. 1878, 24th April. N° 1644.

Recording and Reproducing Sounds.

LETTERS PATENT to Thomas Alva Edison, of Menlo Park in the State of New Jersey, United States of America, for the Invention of "IMPROVEMENT IN MEANS FOR RECORDING SOUNDS, AND IN REPRODUCING SUCH SOUNDS FROM SUCH RECORD."

PROVISIONAL SPECIFICATION left by the said Thomas Alva Edison at the Office of the Commissioners of Patents on the 24th April 1878.

THOMAS ALVA EDISON, of Menlo Park, in the State of New Jersey, United States of America. "IMPROVEMENT IN MEANS FOR RECORDING SOUNDS, AND IN REPRODUCING SUCH SOUNDS FROM SUCH RECORD."

My present improvements are for more fully developing and perfecting the device heretofore invented by me, and known as the "phonograph." By extensive experiment and research I have been enabled to obtain very perfect articulation and to produce a record in a convenient form for preservation.

The sound vibrations are made to move a point that by preference is a diamond or other very hard substance and of a peculiar shape. The sound vibrations in the atmosphere act upon a diaphragm or other body capable of motion, and the same moves the indenting point, and acts as a phonograph. The indented material is properly designated a phonogram, and it is preferably metallic. Sometimes tin-foil is used upon a grooved surface; sometimes a thin sheet or leaf of metal is placed upon a piece of paper having a surface of paraffin or similar material. Sometimes the metallic surface is copper, and where a matrix has been made of steel or iron by electrotype deposit, or otherwise, upon the phonogram it may be hardened and used for impressing a sheet or roller of metal, and thereby the original phonogram can be reproduced indefinitely in metal that may be hardened and used for any reasonable length of time to utter the sentence, or words, or sounds phonetically.

The instrument or portion of the instrument that reproduces the sound from the

phonogram I term a "phonet." In order to facilitate production, use, and preservation of the phonograms I employ a ring or margin of thick paper or pasteboard, caused to adhere to the foil or sheet by resinous substance; this is used as a gauge in placing the sheet in the instrument or replacing the same in the phonet. I find that a disc revolved by gearing, and a weight or spring, and the movement regulated by a fan or governor, is a convenient device for presenting the surface to be indented to the phonograph, and the phonograph is on an arm that swings towards and from the centre of the disc, and is guided by grooves or other convenient mechanism.

The phonet device takes the place of the phonograph device when the sounds are to be reproduced.

When the sheet of material is wrapped around a cylinder its edges are passed down into a slit and held firmly. Either the cylinder may be moved endwise by a screw, or the phonograph or phonet devices be moved along the cylinder, and where the same sound is to be reproduced periodically, as calling out the hours of the day in a clock, or reproducing the sounds of animals in toys, the phonet is to be brought to the place of beginning automatically.

The phonographic devices employed by me are preferably a diaphragm of metal, against which the sound vibrations act. Sections of rubber tube applied to the surface act as dampers to prevent false vibrations; pieces of felt or similar yielding material may be used for the same purpose, and a small delicate hoop of spring metal between the diaphragm and the indenting point renders the phonogram more perfect than it would be if the diaphragm acted upon the point direct. A similar effect is produced by a disc upon the arm that carries the point, said disc being so close to the diaphragm that the atmosphere will produce the vibrations. It is often advantageous to use a case between the mouth of the speaker and the diaphragm to gather or hold the sound, and in some instances the head of the speaker should be inserted into this case up through a hole in the bottom. The mouth-piece is sometimes slotted or perforated, and has irregular edges to re-inforce the hissing sounds, and sometimes a membrane of rubber or gutta percha is fitted to the teeth, and forms a bag between the lips and the diaphragm.

The disc upon the arm that carries the point as aforesaid may be acted upon by a magnet, and the current through a helix from a diaphragm, or the motion of the arm and points may serve to set up a secondary current through such helix in consequence of the motion given by the phonogram to the point. The arm carrying the point in this latter case should be magnetised.

The phonogram may be produced by the direct action of air concentrated to the spot by a funnel terminating with a small hole, the end of the funnel being almost in contact with the moving surface to be indented.

When the foil is perforated instead of indented it can be rolled up in the form of a horn or cylinder, and revolved, and the articulation result from air blown from the end of a small tube passing through the perforations as they are presented in succession. Leverage is sometimes employed between the diaphragm and the phonogram, either to lessen or increase the motion of the phonographic action in recording, or of the phonetic action in speaking, and for recording quartette, trio, and other characters of singing, two, three, four, or more phonographic devices are employed upon one cylinder or plate, and the sounds will be reproduced by corresponding phonets; or where singing is conveyed through tubes to one diaphragm the phonographic record will be the combined tones, and the reproduction by the phonet will be complete and correct.

I find that an arm at right angles to a diaphragm, with a point resting upon the phonogram, will reproduce the tones by the weight and leverage of the arm moving the diaphragm. The phonogram may be in the form of a disc, a sheet, an endless belt, a cylinder, a roller, or a belt, or strip, and the marks are to be either in straight lines, spiral, zig-zag, or in any other convenient form, so long as the apparatus is adapted to bring the same in contact with the phonet or speaking part of the apparatus, and the reproduction of the phonogram from a matrix or copy in relief

of an original phonogram may be made upon a belt, roller, cylinder, plate, or other convenient surface.

For amusement and instruction this phonograph is capable of extended use. For instance, a revolving cylinder containing phonograms of the letters of the alphabet and phonet keys, with corresponding letters on them, can be used in teaching the alphabet; and phonogram sentences, speeches, and other matters can be spoken by the phonet and repeated by the learner without the eyesight being called into use. For amusement or instruction the phonogram can be of a dog's bark, a rooster's crow, a bird's song, a horse's neigh, a lion's roar, and the like, and the phonogram can be used in a toy animal with a single phonet for the reproduction of the original sound.

This phonograph or speaking machine applied to a mask produces a semblance of vitality if the phonogram is made to operate upon moveable lips by levers, and in the production of such a phonogram a portion of the surface is to be indented by delicate levers and points, receiving motion from the lips during articulation; thereby a correct reproduction of the motion of the lips is obtained.

In connection with the phonet it is important to avoid the sound that usually results from the rubbing action of the phonogram upon the point. I am enabled to prevent this by an electric action between the point and the phonogram. In this case the phonogram should be of iron, and the point of steel and the parts magnetised so as to slightly repel each other; the point will follow the undulations and reproduce the sounds by the phonet. It is important that the point used in the phonet correspond in shape to that of the phonograph, but slightly smaller, so as to follow the bottom of the depressions without contact upon the sides. The diaphragm or other body employed in the phonet to receive motion from the phonogram is connected with a funnel of paper or other resonant substance that acts as a sounding board to render the phonet louder and more distinct.

SPECIFICATION in pursuance of the conditions of the Letters Patent filed by the said Thomas Alva Edison in the Great Seal Patent Office on the 22nd October 1878.

THOMAS ALVA EDISON, of Menlo Park, in the State of New Jersey, United States of America. "IMPROVEMENTS IN MEANS FOR RECORDING SOUNDS, AND IN REPRODUCING SUCH SOUNDS FROM SUCH RECORD."

This Invention consists in means for recording in permanent characters the sounds made by the human voice in speaking and singing, those made by musical instruments, birds, animals, or any sound whatever, and in means for reproducing those sounds at any desired time.

The sound vibrations act upon a diaphragm or other body capable of motion: this diaphragm is at the back of a chamber provided with an opening or mouth-piece, and to this diaphragm an indenting point is secured. This instrument I term a "phonograph." The phonograph is adjusted to position with its indenting point contiguous to a moving surface covered with a thin sheet of metal foil or other suitable material, or else the surface with the metal foil is stationary, and the phonograph movable. The surface upon which the metal foil is secured is by preference grooved spirally, and this indenting point indents the foil in the line of this groove as the diaphragm is moved back and forth by the sound vibrations: these indentations are a record of the sound waves, and form the characters for reproducing the sounds. This indented sheet I term a "phonogram." The instrument or portion of the instrument that reproduces the sound from the phonogram I term a "phonet." It is similar in construction to the phonograph, being provided with a diaphragm and point, but the mouth-piece is by preference funnel-shaped to render the sound loud and distinct. The sounds are reproduced by the phonet being adjusted to place so that the point of its diaphragm is at the beginning of the spiral line of indentations, and as the surface containing the indented foil is moved the diaphragm of the phonet is vibrated by the point passing from one indentation to the next, hence the diaphragm receives the same movement from the indentations as when making those indentations, consequently the sounds made by the phonet will be the same as those that operated upon the diaphragm of the phonograph.

In the Drawing Fig. 1 is a section of the phonograph and sectional elevation of the mechanism for presenting the surface to be indented: and Fig. 2 is a plan of the same.

The phonograph is made of the body portion *a*, diaphragm *b*, and indenting point *c*. The body portion *a* has a central opening forming the mouth-piece into which the person speaks, or through which opening the sound vibrations pass to act upon the diaphragm, and the diaphragm is secured at its edges to the body *a*, leaving a space between the body and diaphragm in order that the diaphragm may vibrate freely. The indenting point should be a diamond or other very hard substance. The diaphragm is made of a thin sheet of iron or other material, and it is preferable to place the indenting point upon a delicate spring arm c^2, and to employ a short piece of rubber tubing c^3 between the spring and diaphragm: this rubber acts as a damper to prevent false vibrations of the diaphragm. The phonograph is upon a lever arm *i* pivoted at *5* to the vertical stud *6*, so that the phonograph may be raised or lowered vertically, or moved horizontally for a purpose hereafter explained.

It is now to be understood that if a person speaks with his mouth near the mouth-piece of the phonograph the sound vibrations will act upon the diaphragm, and vibrate it, and communicate to the indenting point a similar movement, and

that if a piece of metal foil or other material susceptible of being indented is placed beneath or behind the indenting point and caused to move regularly, or the indenting point moved over the material, that said material will be indented and form a perfect record of the sound vibrations. I will now describe the means for sustaining the sheet to be indented, and the mechanism for moving the same:—*d* is a disk or plate secured to and turning with the shaft *c*, and hinged to this disk is a ring frame *f*; this disk *d* has two spiral grooves 3, 4, in its surface. There are pins 2, 2, upon the surface of the disk, and holes at corresponding places in the ring frame; the sheet to be indented is of a size and shape to correspond with that of the disk *d* and frame *f*, and said sheet has holes in it corresponding to the position of the pins 2, 2, and these holes form register marks in placing or replacing the sheet upon the disk *d*, and after the sheet is so placed the ring frame *f* is brought down upon the sheet and holds it firmly in place. There may be a central opening in the indented sheet of a size slightly larger than the space occupied by the spiral 3, and the outer edges of the sheet are stiffened by a ring of thick paper or pasteboard caused to adhere by glue or other adhesive material. The surface of the disk *d* is made with two spiral grooves 3 and 4 as aforesaid; the groove 3 is a guide for a pin that is upon an arm *g* on the phonograph, and the groove 4 is for the indenting point *e*. As the disk and sheet are revolved the groove 3 causes the indenting point to occupy a position immediately over the line of the spiral 4, and the indentations will be made upon the sheet of foil in a line corresponding to that of the spiral 4, shown in Fig. 2. The indentations made in the foil are a complete record of the sound vibrations that acted upon the diaphragm *b*, and from this indented sheet, which I term a "phonogram," the sounds are reproduced. The phonograph is carried outwardly by the spiral 3, and in so doing the parts swing upon the vertical stud 6. By depressing the outer end of the lever *i* the phonograph is raised so that it can be swung aside from the disk *d* to allow of the ring frame *f* being thrown back and the indented sheet or "phonogram" removed from the disk. The shaft *c* is revolved by a weight or spring, and gearing at *h*, and the spring is wound up by moving the lever *k* back and forth, which acts upon a ratchet and pawl of ordinary construction; *l* is a lever provided at its outer end with an inclined groove, in which is a pin on the lever *m*, and the other end of this lever *m* is connected with the coupler m^1 by moving the lever *l* one way or the other, the shaft *c* will be connected to or disconnected from the gearing *h*, and hence the disk *d* stopped or started at pleasure without interfering with the motor. As it is necessary that the shaft *c* should be revolved with uniformity I provide a governor at *s* to prevent the apparatus revolving too rapidly; and this may be made as in Figs. 1, 3, & 4, in which there are metal blocks *o* at the ends of spring arms from a cross head on a shaft that is driven by the gearing *h*, said blocks swinging radially and acting against the interior of a stationary cylinder *p* if the speed becomes too great, thereby checking the speed by the friction of the blocks against the cylinder. These spring arms may be secured at one end to a prismatic block as shown in Fig. 5. It is preferable to cover the surface of the blocks *o* next the cylinder *p* with felt or similar material that will slide upon the interior surface of the cylinder *p*, but produce more or less friction, according to the centrifugal action.

The guide spiral 3 may be dispensed with, and either of the devices shown in Figs. 6, 7, 8, or 9 made use of. In Figs. 6 and 7 the shaft *c* projects above the surface of the disk *d*, and there is a tooth upon the shaft contiguous to a rack bar extending from the phonograph, hence each revolution of the shaft, the rack bar, and phonograph will be moved the space of one tooth, consequently the lines of indentations will be parallel and concentric to the shaft *c*, excepting at the places when the tooth acts to move the rack bar and phonograph outward or inward. In this case the spiral grooves are cut to correspond to the feed. In Fig. 8 a worm upon the shaft *c* acts upon a worm pinion to revolve the shaft c^3, and the worm at the other end of this shaft c^3 acts upon teeth around the base of the lever *i* on the stud 6. By this device the phonograph will be moved outward gradually, and the

line of indentations will be in a spiral corresponding to the continuous spiral groove in the plate *d*.

In Fig. 9 the shaft *e* is made with a fusee at p^1, and one end of a swinging arm connected to the phonograph takes against the same. The spirals of the fusee gradually move outward the phonograph, as the disk and shaft are revolved, and the line of indentions will be spirally the same as that made by the spiral 3.

In Fig. 10 the shaft *e* is provided with a screw pinion meshing with teeth upon a cam wheel 7. This gives the same movement to the phonograph as the spiral groove 3.

In Fig. 11 the guide groove 3 for the arm and pin *g* is upon a disk d^1 upon the shaft *e*, but the groove 3 occupies the same relative position upon the disk d^1 as the groove 4 upon the disk *d*, so that the phonograph is moved outwardly by the groove of the disk d^1, swinging both the arms *g* and *i* upon the vertical pivot 6.

Instead of the sheet of metal foil being upon the disk *d* it may be wrapped upon a cylinder *q*, as in Fig. 12. In this case the cylinder is upon a shaft e^1 revolved by the gearing at h^1, and upon said shaft there is a right and left hand screw at k^1, and there is a corresponding double spiral groove in the surface of the cylinder *q*. The phonograph is secured to a sliding shaft l^1, and said shaft is moved endwise back and forth by the screw k^1 acting upon an arm m^2 that is secured to the said shaft l^1. As the phonograph is moved in one direction the line of indentations is made spirally in the foil on the cylinder *q*, and when the arm m^2 reaches the end of the screw it willb e moved in the other direction by the reverse screw thread, and the phonograph will make a second spiral line of indentations that will cross the first spiral line. This feature is especially available for a phonet where the surface of the cylinder *q* is formed of an electrolyte or other copy of the phonogram, so that the words or sounds may be reproduced automatically and at intervals if desired. It is preferable to make use of a thin metal plate n^2, see Figs. 13 and 14, pivoted at one end and fitting within a longitudinal groove in the surface of the cylinder *q* for securing the edges of the metal foil and holding it securely upon said cylinder. The top of this plate n^2 is flush with the surface of the cylinder, and grooved to correspond with the grooves in the cylinder, so as not to interfere with the indenting point. A wire may replace this device, such wire being secured by arms at each end of the cylinder, and raised and lowered in and out of the groove by a cam or otherwise. I find that an interruption of one-eighth of an inch space where there is no recording is not detected by the ear.

The apparatus shown in Figs. 13 and 14 is similar to that shown in Fig. 12, except that the phonograph is stationary and the cylinder moves horizontally, and the shaft e^1 is only provided with a screw thread in one direction, hence the cylinder will have to be moved back by hand to bring it to place if desired to reproduce the sounds from the phonogram, or to position the phonograph if a new sheet of foil is to be indented after the first one has been removed. This is readily accomplished by raising the arm o^1 and its tooth from the screw k^1, which leaves the shaft e^1 and cylinder free to be moved back and forth. In Fig. 15 the phonograph is fitted to move horizontally instead of the cylinder *q*, as in Fig. 12, but the shaft e^1 is provided with a screw thread in one direction only, hence the phonograph has to be positioned by hand after the arm o^1 has been raised from the screw k^1. In Figs. 12 and 15 the phonograph can swing upon the shaft l^1 to raise the indenting point from the cylinder *q*, and allow for the removal or insertion of a sheet of foil, and there is a stop at 8 for adjusting the position of the phonograph when brought down to indent the foil.

In Figs. 13 and 14 the phonograph is upon an arm pivoted at 9, so that it can be swung horizontally away from the cylinder *q* for the purpose aforesaid, and the adjustable stop 8 is also provided.

Thus far I have described the "phonograph" or instrument upon which the sound vibrations act, and which instrument acts to indent the sheet of foil and produce the "phonogram" or record of such sound vibrations. Mechanism has also been described for presenting the sheet of foil to be indented by the phonograph.

Specification

A.D. 1878.—N° 1644.

Edison's Improvements in Recording and Reproducing Sounds.

I will now describe how the sounds are reproduced from the phonogram. If it is desired to reproduce the sounds from the phonogram in the same instrument in which the phonogram was produced it is only necessary that the indenting point *c* be made to traverse the line of indentations in the phonogram, and that a funnel-shaped mouth-piece, shown by dotted lines in Fig. 1, be added to the phonograph to aid in increasing the loudness and distinctness of the sound. The instrument in this form I term a "phonet."

In the instrument shown in Figs. 1, 2, 6, 7, 8, 9, 10, 11, 13, 14 and 15, the phonet requires to be positioned by hand, as before explained, in order that the point *c* may be placed at the beginning of the spiral line of indentations. As the point *c* passes from one indentation to the next, either by the foil being moved beneath said point, as in Figs. 1, 2, 6, 7, 8, 9, 10, 11, 13, and 14, or by the point moving over the foil, as in Figs. 12 and 15, the diaphragm *b* receives a movement corresponding to the depth of the indentations, and corresponding also with the same movement it received from the sound vibrations when making those indentations, hence air waves will be produced by the movement of the diaphragm that will make sounds by passing through the mouth-piece of the phonet that will be exactly the same as the sounds that acted upon the diaphragm of the phonograph.

The material upon which the record is made may be of metal foil, such as tin, iron, copper, lead, zinc, cadmium, or a foil made of composition of metals. Paper or other materials may be used, the same being coated with paraffine or other hydrocarbons, waxes, gums, or lacs, and the sheet so prepared may itself be indented, or the material, say paper, may be made to pass through a bath of hot paraffine, and thence between scrapers. Thin metal foil is now placed on the material, and the sheet passed through rollers, which give it a beautiful smooth surface. The indentation can now be made in the foil, and the paraffine or similar material, and the indenting point, does not become clogged with the paraffine in consequence of the intervening foil. If the copper foil, or tin foil with copper surface is used, and a matrix of iron or steel made by electrotype deposit or otherwise upon the phonogram, such matrix may be hardened and used for impressing a sheet or roller of metal as hereafter mentioned: thereby the original phonogram can be reproduced indefinitely in metal that may be hardened and used for any reasonable length of time to utter the sentence or words or sounds phonetically.

I will now briefly describe some modifications in the construction and operation of the phonograph and phonet.

In Fig. 16 the indenting point *c* is upon a spring arm c^2, as in Figs. 1 and 2, but there are short sections of rubber tube c^8 at each side of the diaphragm *b* to dampen the diaphragm and prevent false vibrations. In Fig. 17, the rubber of the diaphragm acts against the outer end of the arm c^3 to increase the leverage and lessen the depth of indentations in the foil and allow of the record being made in less yielding material than tin foil. Fig. 18 shows a modification of the last-mentioned device, the pressure being applied to the arm c^3 between the indenting point and the support for the arm so as to increase the depth of the indentations. Fig. 19 shows the arm c^3 made as a lever with a spring. Fig. 20 shows the indenting point upon the center of a spring bar that is firmly held at each end: the bar is connected at its center to the diaphragm *b* by a string or otherwise. Fig. 21 represents the diaphragm *b* as of concave form instead of flat. Fig. 22 shows the indenting point upon a spring secured to the diaphragm.

Fig. 23 shows a disk upon the spring c^2 of the indenting point: this disk is placed quite close to the diaphragm and is moved by the air as the diaphragm is vibrated, the disk being so close to the diaphragm that the two will vibrate together, as air cannot pass between or escape as rapidly as the vibrations take place.

Fig. 24 shows the diaphragm vibrated by electro-magnetism: in this case the diaphragm is to be of iron, and the power of the electro-magnet will be varied by a

rise and fall of electric current passing through the helix of the electro-magnet; this rise and fall of electric tension is to be produced by the action of sound upon a diaphragm and connections in an electric circuit. Fig. 25 shows the method of vibrating the indenting spring and point by the direct action of an electro-magnet without the use of a diaphragm, the electric tension in the helix being varied by sound vibrations upon a diaphragm. Fig. 26 shows the spring arm e^3 connected to one end of a permanent magnet so as to highly magnetize the reproducing point; the foil should be of iron. When the point passes an indentation there will be less attraction than when passing no indentation; this will give good articulation free from the scraping noise of the point on the foil, for in this case it does not touch the foil, but is worked by magnetic attraction. Fig. 27 represents two instruments in connection with the cylinder g; in this case the phonet and the phonograph are separate. The phonograph records in the usual manner, but the phonet has its diaphragm set in motion by the rise and fall of the lever e^3. This reduces the scraping noise of the foil and acts by leverage, and a slight tension to move the diaphragm as the phonogram is moved beneath the point e. Fig. 28 shows an arrangement whereby four persons may speak simultaneously and have records made in separate parallel lines upon one cylinder, and the phonogram will reproduce the sounds the same as though it contained the record of but one voice. Fig. 29 shows a single phonograph adapted to receive the voices of three persons as in singing; the sounds made by the three voices are conveyed through flexible or other tubes to the diaphragm, and will be recorded in a single line of indentations, but when reproduced by the phonet the sounds uttered will correspond to the three voices.

In Fig. 30, the foil is sustained upon a hollow cylinder with a funnel-shaped end. The record is made upon the foil in the usual manner by the phonograph, excepting that holes are made entirely through the foil. A nozzle with a small opening is placed so that it will always be opposite the line of perforations as the cylinder is revolved. This nozzle is connected to a source of compressed air or other fluid, and every time a perforation comes opposite the nozzle, a puff of air passes into the cylinder and a sound is produced upon the principle of the siren. The nozzle may be placed on a spring to keep the end of the nozzle in contact with the line of perforations.

Fig 31 shows the phonograph as made with a large chamber between the diaphragm and the mouth-piece; this is especially useful in collecting sound when the person speaking or the sound to be recorded is made several feet from the instrument. Fig. 32 shows a device whereby the indenting point may be dispensed with in the phonograph. The funnel forming the phonograph is made with a diaphragm at the larger end or mouth-piece, and a very small hole at the pointed end adjacent to the foil on the cylinder g; this foil should be very thin so that the indentations will be made by the direct action of the air waves as concentrated by the funnel without the interposition of the indenting point. Fig. 33 shows a phonet in which the phonogram or sound record has been made upon an endless belt; this is a convenient arrangement for toys, as the same may be made to imitate the bark of a dog or other noise made by an animal; and this belt may be of steel or other hard material that allows the same to be used for a long period of time.

Fig. 34 is a perspective view showing a double phonet, there being a spiral line of indentations on each side of the revolving disk d, one phonet coming into action as the other finishes; in this case the spirals should be in opposite directions, so that the disk continuing to revolve in the same direction moves one phonet from the center outwards, and then the other phonet is connected and moved back towards the center; this may be used as a toy.

Fig. 35 represents a phonet in which the phonogram containing a sentence, speech, words, or other sound record is upon a belt or strip wound upon a reel; this belt is drawn along gradually and wound upon the second roller by any suitable mechanism, and as the phonogram is thus moved it actuates the

phonet *c*, *b*. Fig. 36 shows a phonograph or phonet similar to that shown in Fig. 12, the cylinder *g* is revolved, but remains in one position, and the phonograph or phonet is movable back and forth over the cylinder. In this instance the arm m^3 is extended beyond the screw k^1, and passes beneath the inclined spring guide m^5, when the screw is carrying the arm and phonograph towards the right; as the arm m^3 passes from beneath the end of the guide m^5 it is no longer held to the screw, and the arm m^2 and phonet are lifted by the guide m^2 as the springs m^6 draws the shaft, phonograph, and arm, along to the place of beginning, at which place the arm m^2 drops off the end of the inclined guide m^5 into the thread of the screw, and as this revolves it carries the arm along beneath the guide m^5 as before, Fig. 37 represents the phonograph or phonet upon a pivoted arm, so that it may swing across or at right angles to the line of movement of the intended material or phonogram. In this case the line of indentations may be lengthwise of the belt, or across the same as in the arc of a circle. Fig. 38 shows a phonograph similar to that shown in Fig. 31, except that the sound chamber is of a different shape.

Fig. 39 shows a mouth-piece with an orifice of soft rubber to fit the mouth or the lips of the person speaking, so that all sound waves will be confined to the chamber and diaphragm. Fig. 40 shows the mouth-piece of the phonograph made with cross slots with irregular edges. Fig. 41 shows the mouth-piece as perforated with numerous holes. Fig. 42 shows but one opening in the mouth-piece; the edges of this are irregular. These irregular edges reinforce the hissing sounds, and cause a more perfect phonogram to be produced. Fig. 43 represents a mouth-piece of mica with a central opening protected at its edges by a wooden ring. In Fig. 44 the diaphragm *b* is of wire gauze with a backing of paper connected to it by any suitable cement, and there is a ring of stiff paper at the edges of the gauze disk to strengthen it. Fig. 45 represents a diaphragm *b* of parchment or similar material stretched tightly within the frame b^6 by cords and screws. The cords may be of different lengths and tension, and respond to and reinforce certain sounds. Fig. 46 shows a mouth-piece for the phonet made in imitation of the human mouth. Fig. 47 represents the body portion of the phonograph or phonet made triangular, and the diaphragm is of corresponding shape. Fig. 48 represents three cylinders, each provided with a phonograph or phonet; this is useful in recording and reproducing three-part singing or music. Fig. 49 represents a phonet made as a tube, with flaring or trumpet-shaped ends, and with two diaphragms 15, 16, placed crosswise of the tube so as to form an air chamber. There is a third diaphragm *b*, which is vibrated by the movement of the reproducing point *c*, and said diaphragm gives motion to the air in the chamber, and vibrates the diaphragms 15, 16, which latter produce air waves, and the sounds issuing from the two trumpet-shaped ends will blend and increase the volume of sound. Fig. 50 represents a device whereby deep indentations are made in the metal foil. Two diaphragms are employed, the first (b^2) is vibrated by the sound vibrations, and controls a valve b^7 in a tube connected with a source of compressed air or other fluid; this valve b^7 allows more or less air to pass to the diaphragm *b*, according to the vibration of the diaphragm b^2, hence the diaphragm *b* will vibrate in harmony with the diaphragm b^2, but it will be acted upon by greater force, and consequently the indentations will be deeper in the foil than if the diaphragm *b* was acted upon simply by the sound vibrations of the voice. Figs. 51 and 52 represent a device that may be used with a phonet to increase the loudness of the sounds reproduced. The sound vibrations from the phonet are conducted by a tube shown by dotted lines in Fig. 51, to the diaphragm b^3 that controls a valve b^7 in a tube connected with a reservoir of air or other fluid under pressure, and the air as it escapes by the valve passes into the trumpet-shaped end of the tube, and produces sounds that are very loud and clear, and are a reproduction of the sounds resulting from the use of one of the phonets before described. This same apparatus may be used to reproduce with louder utterances a person's voice, the sound from the voice being used to vibrate the diaphragm b^3, and thereby regulate the air waves escaping from the valve b^7 into the trumpet. Fig. 53 shows the speaker's head within a box or case; in this instance nearly all

the sound vibrations act upon the diaphragm. Figs. 54 and 55 illustrate how the movements of the lips in speaking may be recorded and reproduced. In this instance, a lever applied to the diaphragm carries the indenting point *c*, Fig. 55, and the end of this lever is placed in the mouth of the speaker, and the movement of the lips regulates the indentations in the foil. A similar apparatus shown in Fig. 54 within a case is connected to the movable lips of a mask, so that these lips open and close as in articulation, at the same time that the sound vibrations are given by the phonogram to the phonet. Fig. 56 represents a toy phonet in which the phonogram strip 35 is secured at one end to a cylinder upon which it is wound. By pulling upon the strip it is unwound, and a rubber cord 37 is wound upon the shaft of the cylinder. When the hand is removed from the indented strip, the rubber cord rotates the shaft and winds up the phonograph upon the cylinder, and the sounds are reproduced in the phonet by the phonogram acting upon a point and diaphragm *a*. The movement of the shaft is regulated by the fan, worm, and pinion 38. In Fig. 57, the cylinder for moving the phonogram strip is shown as provided with pins that enter holes in the edges of the strip; this causes the strip to be fed along very regular. In Fig. 58, the cylinder with pins is shown as made with heads to act as guides for the strip. Fig. 59 shows a re-indenting device for amplifying or increasing the size of the indentations. There are two rollers, one of which a^4 travels faster than the other a^3, and there is a lever 40 pivoted at 41, and provided with a point *c* for each cylinder. One point follows the indentations in the cylinder a^3, and the other rests upon a^4, and as this travels the fastest, the indentations made therein will be longer and also deeper by the point being at the outer end of the lever. In Fig. 60, one roller 42 of the pair is made of hardened metal with the sound record in relief. This is obtained by electrotype or other process from an iron foil or other metal phonogram, and this roller is used to indent strips or sheets of foils or rollers to produce copies that can be used with the phonet. Fig. 61 represents a roller 42 of hardened metal with the record in relief, and arranged so as to knurl or indent the phonogram in a roller 43 of soft metal that is to be pressed against the roller 42 by a screw or other suitable means. The cylinder having a spiral groove in its surface may be made by placing the mould shown in Fig. 62 around a cylinder or shaft, and filling the space between the cylinder and mold with plaster of Paris or other suitable material. The mold is of metal with a screw or spiral rib projecting therefrom, and it is made in two parts and hinged so that it can easily be removed when the plaster of Paris is dry. For amusement or instruction, the phonograph is capable of extended use; for instance, a revolving cylinder, see Fig. 63, containing rows of indentations representing the letters of the alphabet, and provided with keys containing corresponding letters, can be used in teaching the alphabet, and sentences, speeches, and other matter can be spoken by the phonet, and repeated by the learner without the eyesight being called into use. Clocks may be provided with phonogram cylinders or wheels to call off the hours, to give alarms, &c. The phonogram may be upon a strip, sheet, belt, or roller, and it can be of a dog's bark, a rooster's crow, a bird's song, a horse's neigh, and these can be used in toy animals with a simple phonet for reproducing the sound. In copying phonograms, or making duplicates, an original phonogram may receive a deposit of copper or iron in a plating bath; and, if of iron, may be carbonized to convert it into steel and hardened, and then the same should be backed up with type metal, and use for impressing strips or pieces of metal.

A bed of gutta percha, or similar material, may be used to sustain the sheet metal while being pressed. Numerous copies of the original phonogram can thus be reproduced. A plaster cast can be used for producing a copy by pressure. The governor to regulate the speed of the instrument may be made of a pendulum weight 61, see Fig. 64, hung at the lower end of a rod that is provided with an universal joint at 62, and the upper end of the rod is moved around by a crank 63 that is revolved by the train of gearing. As the speed increases the weight will describe a circle of larger diameter, and thereby increase the resistance. The universal joint may be displaced by a spring wire, Fig. 65, that allows of the

movement. A magnet 64 upon the crank arm 63 Fig. 66, may be used to revolve the pendulum by attracting an armature at the upper end of the pendulum rod, and thereby avoid the friction resulting from the contact of the surfaces of the pendulum rod with the crank. In Fig. 67 the diaphragm *b* is represented as connected to a pair of delicate piston valves within a tube 68 that has three ports; one 69, is connected to a reservoir of compressed air, the others, 70 and 71, are connected to a chamber 72 at opposite sides of a diaphragm, so as to vibrate the same in harmony with the diaphragm *b*, but there will be greater amplitude given to the same by the pressure of the air, and by a connection to the phonet diaphragm b^2 the sound produced will be greatly increased.

What I claim as my Invention is,—

First. The combination with the diaphragm and point of a flat receiving surface and means for revolving the receiving surface, and causing the point to follow a volute or spiral line, substantially as represented in Figs. 1, 2, 6, 7, 8, 9, 10, and 34.

Second. The combination with the revolving plate phonograph or phonet of a propelling weight or spring and a governor to regulate the speed, and ensure uniformity of movement, substantially as set forth.

Third. A revolving disk provided with a clamping frame to secure the foil or other material in combination with the swinging arm, diaphragm, and point, substantially as specified.

Fourth. In a phonograph or phonet, a spring introduced between the diaphragm and the point, substantially as set forth and shown in Figs. 16, 17, 18, 19, 22, and 26.

Fifth. In a phonograph or phonet, a rubber spring, or similar device, to dampen the vibration of the diaphragm, and prevent false vibrations, as set forth and shown in Figs. 16 and 21.

Sixth. The combination with the diaphragm in a phonograph or phonet apparatus of a lever to modify the relative action of the diaphragm and point, substantially as described, as shown in Figs. 17, 18, 27.

Seventh. The combination with the diaphragm and point of a permanent or electromagnet, substantially as described and represented in Figs. 24, 25, 26.

Eighth. The method of recording and reproducing two or more sounds or speeches simultaneously, substantially as described, and as illustrated by Figs. 28, 29, and 48.

Ninth. A phonet composed of a perforated sirene and a jet tube, substantially as described, and represented in Fig. 30.

Tenth. The mechanism for producing a phonogram, and employing the same in a phonet, substantially as described, and illustrated in Figs. 32, 33, 35, 36, and 37.

Eleventh. The combination with the phonograph, diaphragm, and point of a sound chamber, substantially as described, and illustrated in Figs. 31, 38, 39, and 53.

Twelfth. The diaphragm and mouth-pieces for a speaking phonograph, substantially as described, and illustrated in Figs. 41, 42, 43, 44, 45, and 46.

Thirteenth. The combination with a diaphragm and its point of two diaphragms for the purposes, and substantially as shown in Figure 49.

Fourteenth. The combination with a diaphragm and valve actuated by sound vibrations a source of compressed fluid and a trumpet, as in Figs. 51, 52, or a phonograph as in Fig. 50, substantially as set forth.

Fifteenth. The combination of two diaphragms with a valve and a source of compressed fluid, as represented in Fig. 67, for increasing the volume of the voice or other sound, as set forth.

Sixteenth. The combination with two or more phonograms of phonet keys for selecting letters or utterances as described, and illustrated in Fig. 63.

Seventeenth. The means for duplicating or reproducing phonograms from an original phonogram, substantially as set forth.

Eighteenth. The combination with the phonograph or phonet of the revolving

crank and pendulum governor, substantially as described and shown in Figs. 64, 65, 66.

Nineteenth. The combination with the phonograph of a lever moved by the lips, and of a lever and phonet to move the lips of a mask, substantially as described, and illustrated by Figs. 55 and 54.

Twentieth. The combination with a phonogram of a clock movement or toy and a phonet for reproducing sounds for clocks or toys, substantially as set forth.

In witness whereof, I, the said Thomas Alva Edison, have hereunto set my hand and seal this 17 day of September, A.D. 1878.

THOMAS ALVA EDISON. (L.S.).

Witnesses,

CHAS. H. SMITH,
76, Chambers St., New York,
HARROLD SERRELL, 76, Chambers St., New York.

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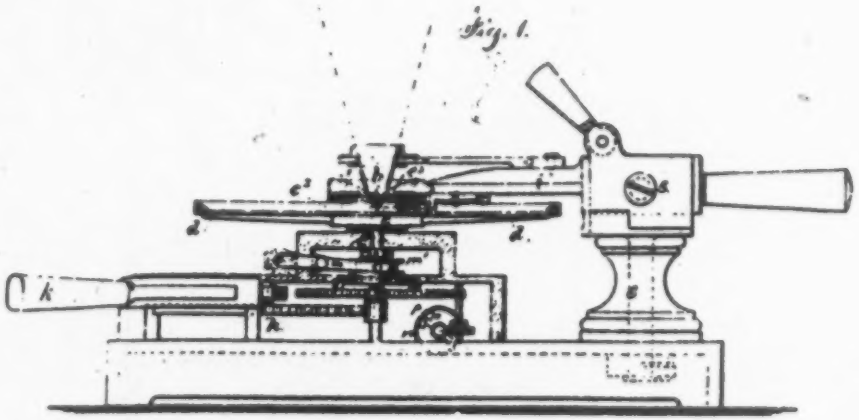
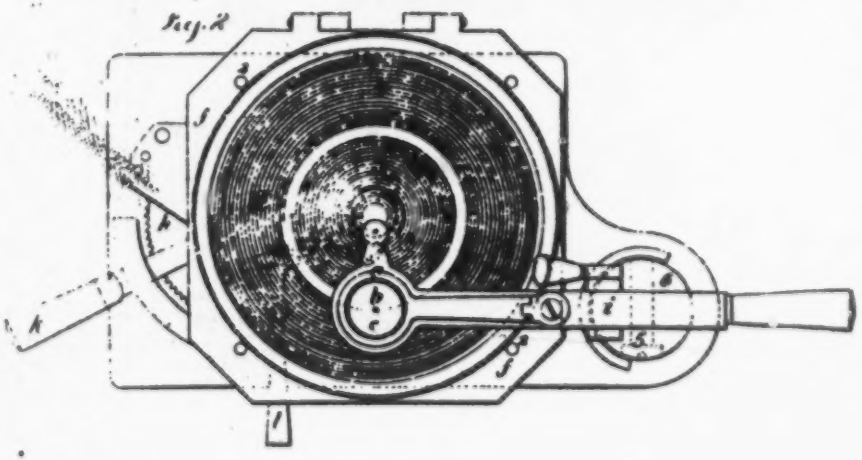
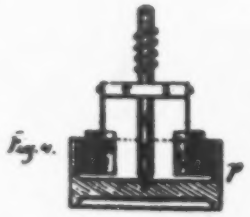
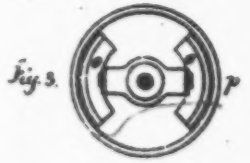
[Wt. 23—250/8/1912

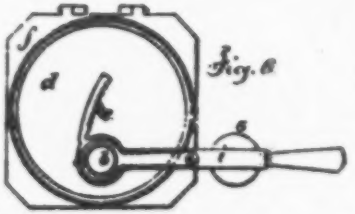
A.D. 1878. April 24. 1644.
EDISON'S Specification

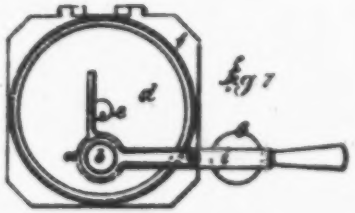


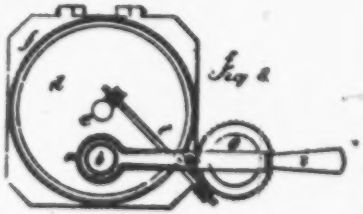


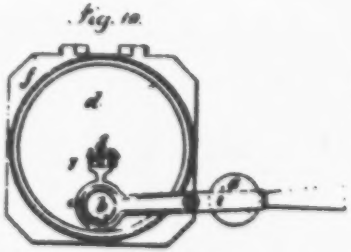












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4 SHEETS
SHEET 1

Fig. 11.

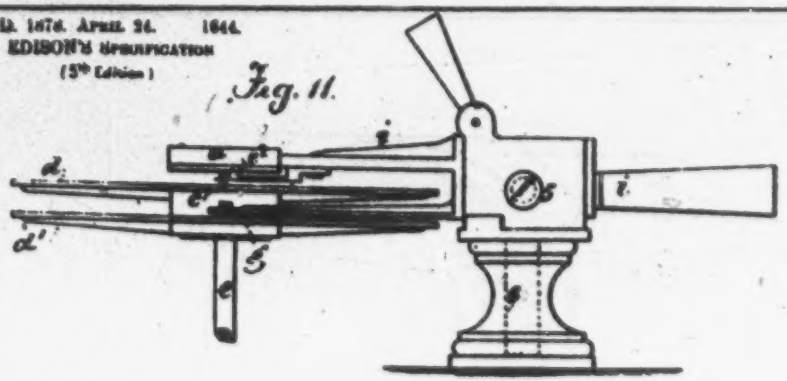
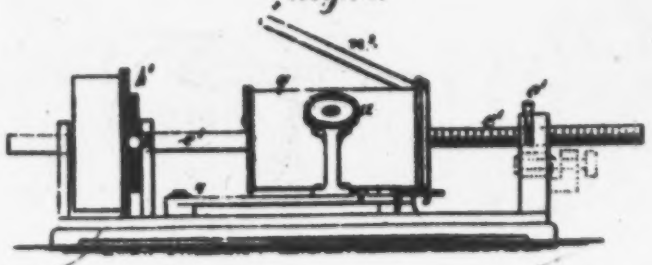


Fig. 14.



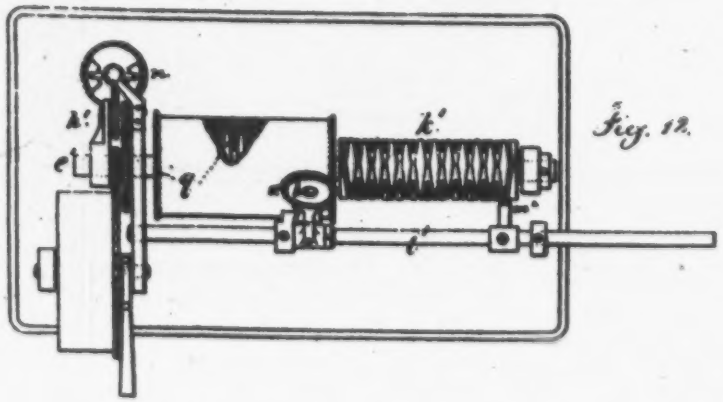


Fig. 12.

Fig. 15

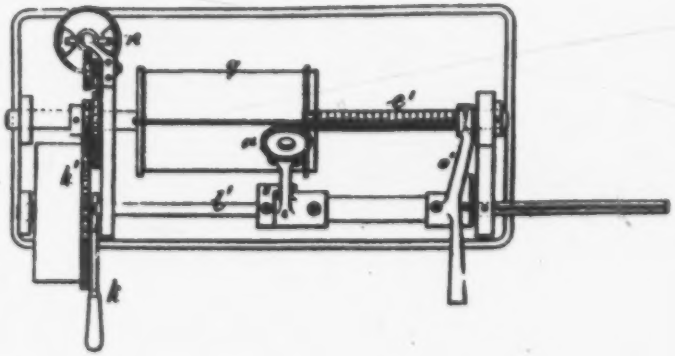


Fig. 13.

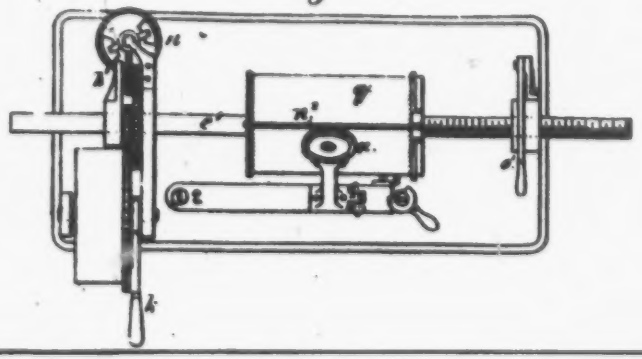


Fig. 16.

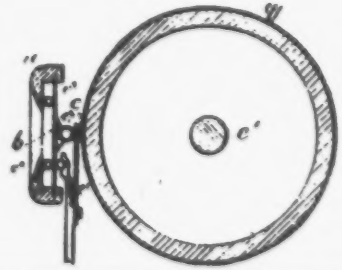
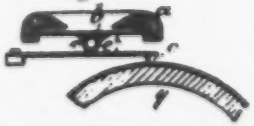


Fig. 17.

Fig. 18.



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4 SHEETS
SHEET

Fig. 20

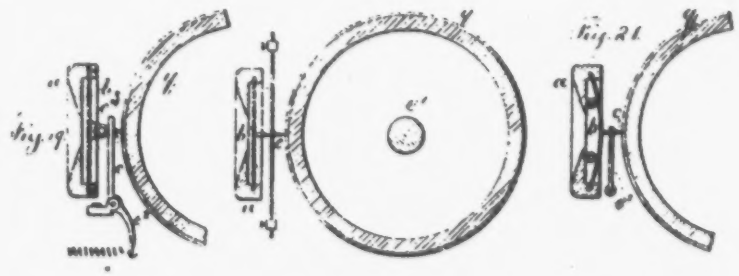


Fig. 21

Fig. 30.

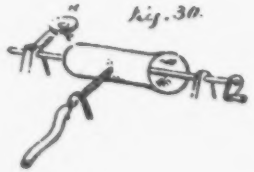


Fig 31

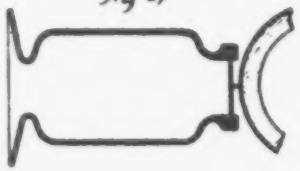


Fig. 32

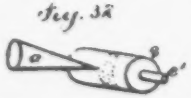


Fig. 33

Fig. 34

Fig 35

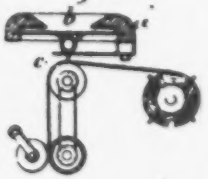


Fig. 23

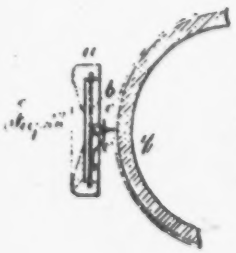


Fig. 24

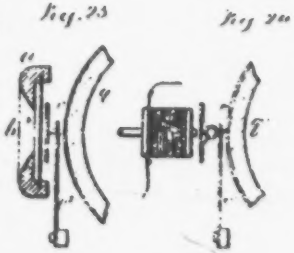


Fig 25

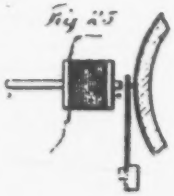


Fig. 36

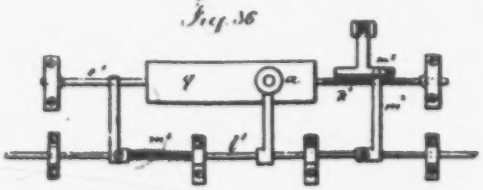


Fig 37

Fig. 43.

Fig. 38

Fig. 39

Fig. 40

Fig. 41

Fig. 42

Fig. 46.

Fig. 44

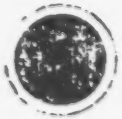


Fig. 45

Fig. 26

Fig. 27

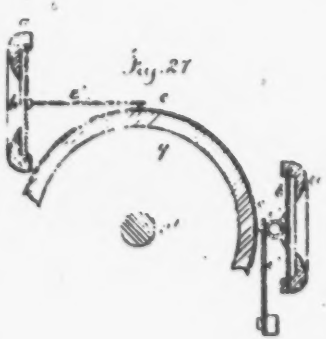


Fig. 28

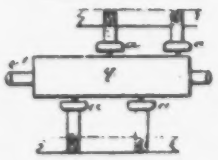
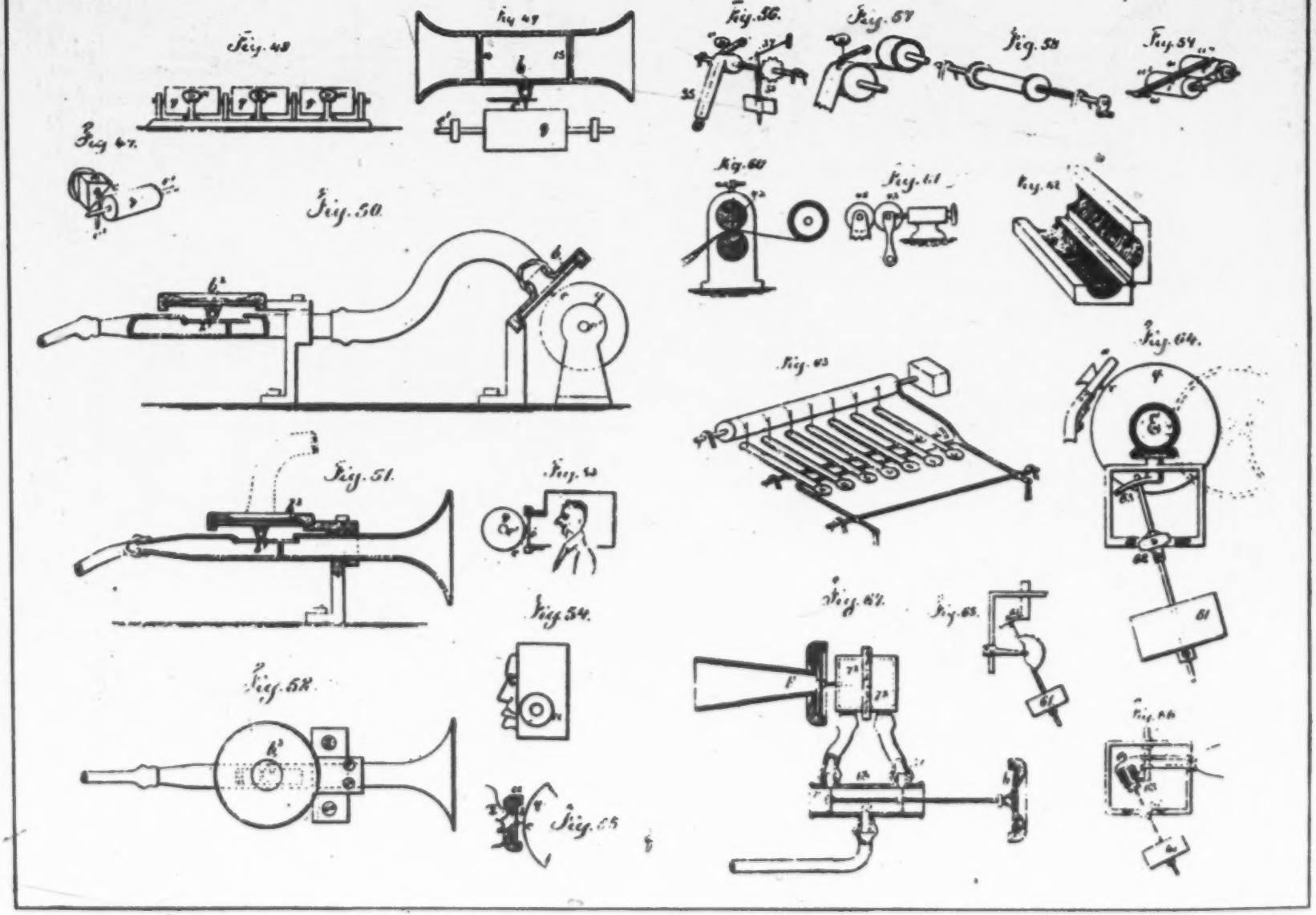


Fig. 29

1317

A.D. 1878. April 24. N. 1644.
EDISON'S SPECIFICATION.
5th Edition.



A.D. 1884, 6th FEBRUARY. N° 2814.

Improvements in Electric Governors.

COMPLETE SPECIFICATION.

We, ANDREW JAMIESON C.E., F.R.S.E., Principal of The Glasgow College of Science and Arts, Glasgow, in the County of Lanark, North Britain, and STEPHEN ALLEY, of The Sentinel Works, Polmadie, in the County of Renfrew, North Britain, Engineer, do hereby declare the nature of our said invention for "IMPROVEMENTS IN ELECTRIC GOVERNORS" and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

Our said Invention has for its object to provide apparatus whereby the action of a combined motor and dynamo-electric machine may be automatically governed or regulated notwithstanding variations produced accidentally or otherwise in the resistance to, or work to be done by the electric current generated. Thus for example, if the dynamo-electric machine is used for actuating a number of incandescent lights arranged in multiple arc, our improved electric governor will bring about a suitable adjustment of the throttle valve of the steam engine or of the equivalent part of any other motor, whenever the action of one or more of the lights is stopped or renewed.

In carrying out the Invention a disk of metal and by preference of copper, made to rotate by the motor, is placed so that its outer part moves through a magnetic field or fields induced by one or more electro magnets excited by means of coils of insulated conducting wire which forms a shunt to the main circuit from the dynamo-electric machine. The same shunt circuit may be that which is used to excite, or to assist in exciting the field magnets of the dynamo-electric machine; or it may be a separate or distinct shunt circuit used only for exciting the governor magnets. The governor disk is connected to the shaft or spindle which carries and turns it by a volute spring or other suitable spring, and in rotating it experiences resistance in passing between the poles or pole pieces of the governor magnets. When one or more of the lights are stopped the strength of the current passing through the shunt circuit becomes increased and by intensifying the magnetic field increases the resistance to the rotation of the disk, and this resistance is additionally increased because of an increase which simultaneously takes place in the speed of the motor. The increased resistance causes a relative movement between the disk and its shaft and this movement is by suitable mechanism made to bring about the adjustment of the throttle valve or equivalent part of the

motor. When the action of one or more of the lights is renewed the strength of current through the shunt circuit and the rotatory velocity of the disk become diminished so as to lessen the resistance to the disk's rotation; and the volute spring then causes a reversed relative movement of the disk which brings about the readjustment of the throttle valve or equivalent part of the motor.

Whilst the improved governor is extremely simple in its construction and action, it has the important practical advantages, that in its operation there are no changes of electric contacts for putting resistances into circuit or for taking out resistances or for other purposes; and that there are no sliding or frictional contacts through which electric currents have to pass.

And in order that our said Invention and the manner of performing the same may be properly understood we hereunto append two sheets of explanatory drawings to be hereinafter referred to and representing our improved electric governor.

Figure, 1, on sheet, 1, of the accompanying drawings is a plan of the governor, figure, 2, on sheet, 2, is a sectional elevation, and figure, 3, is a longitudinal vertical section. In these drawings the same reference letters are used to mark the same or like parts wherever they are repeated.

The governor is carried on a base plate, B, having fixed on it standard bearings, *b* 1, which carry a horizontal shaft or spindle, *s*, having fast on it a pulley, P, for receiving a driving cord from the steam engine or other motor. The pulley, P, is shown as made with two grooves of different diameters, and it might be made with more of such grooves, to suit different ratios of speed between the governor and the driving pulley of the motor. A copper disk, D, made with a thickened rim is fixed to a brass centre, C, which is made with a boss fitted loosely on the shaft, *s*. The centre, C, is also made with a rim, *r*, on one side of it forming a shallow circular box in which there is placed a volute spring, V, having its centre or inner end fixed, like that of a watch spring, to the shaft, *s*, whilst its outer end is fixed to the rim, *r*, of the disc centre, C. The outer side of the volute spring, V, is covered by a small disk, *d*, and a collar, *c*, fixed on the shaft, *s*, after the disk centre, C, is in place, prevents this centre from moving along the shaft. The boss of the disk centre, C, has a screw thread formed on it to work in an internal screw formed in the end of a sleeve or tube, *t*, which is fitted loosely on the shaft, *s*, and can move along it, whilst it is made to turn with it by screws, K, acting as keys in longitudinal grooves formed in the shaft. Additional grooves are provided at suitable parts round the shaft to facilitate the adjustment of the parts. The tube, *t*, is made with bevil surfaces, *l*, to act as frictional bevil wheels; and to engage with one or other of them there is arranged a frictional bevil wheel, L, on a vertical spindle, W, carried in bearings, *b* 2, *b* 3, and formed with a worm or tangent screw, *w*, which gears with a toothed sector, Q, fixed on a rocking shaft, R. When the tube, *t*, is in its middle position neither of its bevil surfaces, *l*, is in contact with the bevil wheel, L; but when from an alteration taking place in the resistance experienced by the disk, D, the disk centre, C, moves faster or slower than the shaft, *s*, then the screwed boss of the disk centre, C, causes the tube, *t*, to move along the shaft, *s*, and to put one or other of its bevil surfaces, *l*, into contact with the bevil wheel, L; and on this occurring the bevil wheel, L, is turned with its shaft W, and the worm, *w*, acts on the sector, Q, and through it moves the rocking shaft, R. The rocking shaft R, is carried in bearings of which one, *b* 4, is shown and may be connected in any convenient way to the throttle valve or equivalent part of the motor.

Two pairs of electro-magnetic poles, M, are arranged to act on the copper disk, D, being placed with their pole pieces N, S, N, S, at diametrically opposite positions at about the level of the shaft, *s*. The cores of the magnets, M, with the bottom connecting pieces, *m* of the two pairs, are fixed by screws to the base plate, B, and the pole pieces, N, S, N, S, are bolted to the tops of the magnet cores, and are placed with their inner ends or faces very near to but not touching the copper disk, D, adjusting screws, *a s*, being provided for setting them at suitable

distances from the disk. The insulated wire for conducting the shunt current for exciting the electro-magnets, M, is coiled on the cores in the usual way being continued from one pole to another in succession, and having its ends, T + and T −, connected in any suitable manner to the dynamo-electric machine.

It is obvious that the details of the apparatus may be considerably modified to suit different circumstances and requirements. The difference in the current through the shunt circuit does not itself directly shift the throttle valve or equivalent part of the motor; but it simply effects an adjustment of the governor details requiring little force, in consequence of which adjustment the power communicated from the motor to the governor is made to effect the adjustment of the throttle valve or equivalent part; and with this arrangement the governor is made much more sensitive than it could otherwise be. The rocking shaft, R, may itself directly shift the throttle valve or equivalent part or it may be arranged to move the valve of a steam cylinder or the like which will shift the throttle valve or equivalent part.

Having thus particularly described the nature of our said Invention and in what manner the same is to be performed we proceed to ascertain the distinctive features of novelty thereof by declaring that what we claim is:—

The arranging or combining together of parts to form an electric governor substantially in the improved manner hereinbefore described; and more particularly the arranging of a copper or other suitable metallic disk to rotate between magnetic poles excited by the electric current in a shunt circuit from the dynamo-electric machine, the changes in the resistance to the disk's rotation and produced by changes in the current and in the rotatory velocity being made to bring about the required adjustments of the throttle valve or equivalent part of the motor.

Dated this fifth day of February 1884.

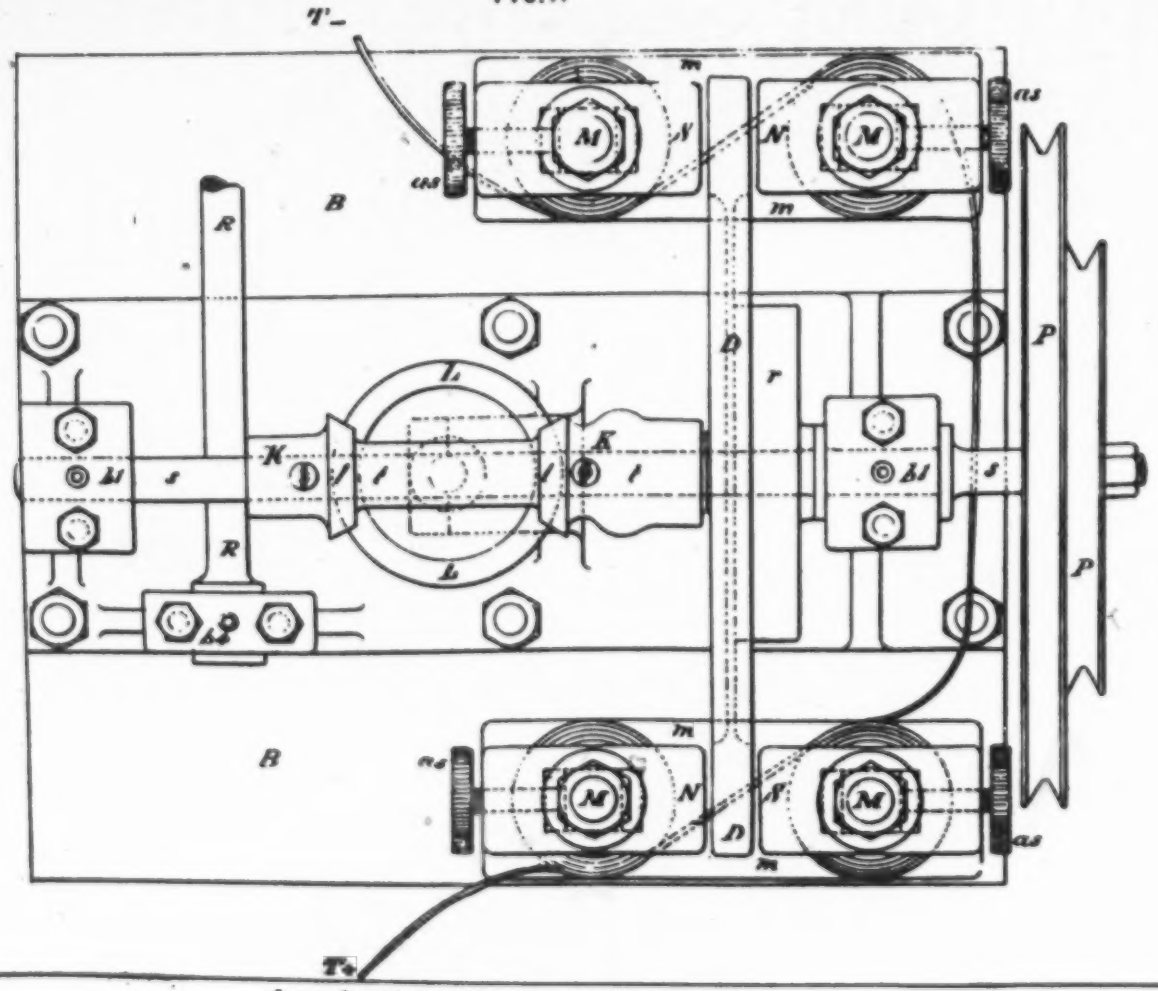
EDMUND HUNT,
Applicants' Agent.

LONDON: Printed by EYRE AND SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty.
For Her Majesty's Stationery Office.

1884.

1382

FIG. 1.



London: Printed by George Edward Eyre and William Spottiswoode.
Printers to the Queen's most Excellent Majesty. 1884.

FIG. 2.

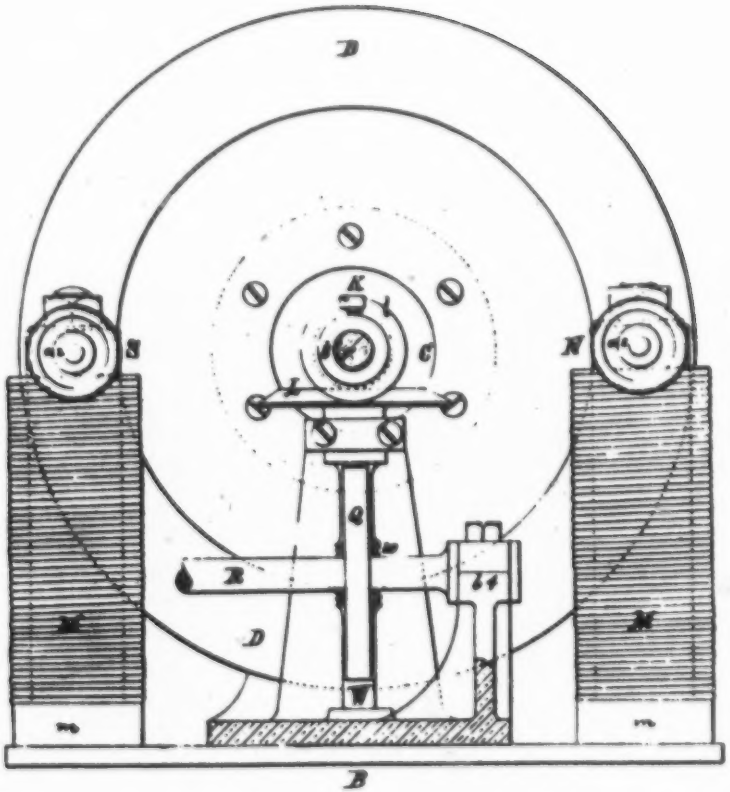
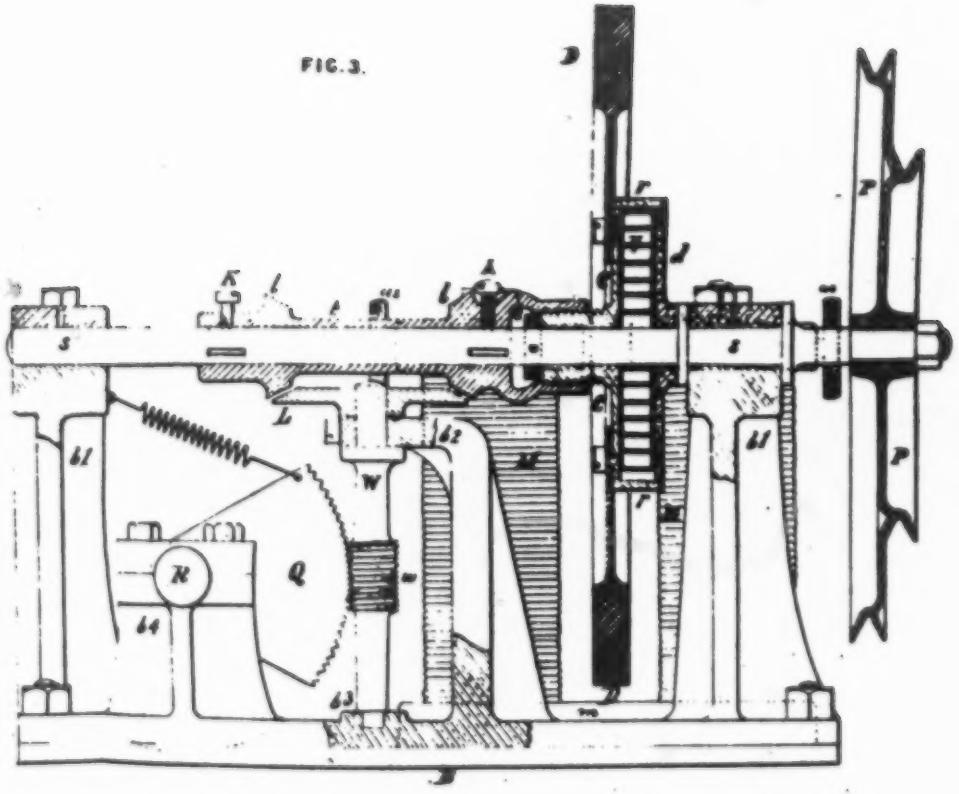


FIG. 3.



1324

N° 21,371 A.D. 1898

(Under International Convention.)

Date claimed for Patent under Sect. 103 of Act, being date of first Foreign Application (in France), } *4th Apr., 1898*

Date of Application (in United Kingdom), 11th Oct., 1898

Complete Specification Left, 5th July, 1899—Accepted, 11th Oct., 1899

PROVISIONAL SPECIFICATION.

Improved Apparatus for Taking and Reproducing Animated Scenes and Sounds.

I, AUGUSTE BARON, of 10, Rue de l'Alma, Asnières (Seine), France, Photographer, do hereby declare the nature of this invention to be as follows:—

This invention relates to a system of apparatus for recording animated scenes and sounds simultaneously and for reproducing the same simultaneously. The apparatus consists of two distinct parts which are so combined as to form a whole for obtaining the above result. The one part consists of a chrono-photographic apparatus for taking a series of photographs of the same moving subject at very rapid intervals, while the other part consists of a phonograph for recording and reproducing in a loud tone, the sounds emitted by the subject during the operation of the chrono-photographic apparatus. The phonographic apparatus is connected to the chrono-photographic apparatus by an electrical apparatus whose movement is controlled by the driving wheel of said chrono-photographic apparatus in such manner as to cause the two apparatus to move together at the same speed, and during the reproduction by projection of the subject photographed the movements will be represented synchronously with the accompanying sounds so that the spectators will both see and hear the scenes and sounds reproduced exactly as in reality.

My invention is illustrated by way of example in the accompanying drawings in which Figure 1 is a side elevation of the chrono-photographic apparatus. Figure 2 is a plan of the chrono-photographic apparatus. Figure 3 is an elevation of the shutter mechanism. Figure 4 is a plan of the electro-motor. Figure 5 is a plan and Figure 6 a side elevation of the commutator. Figure 7 is an elevation of the phonograph. Figure 8 is an end elevation of the frame and rocking support of the phonograph diaphragm. Figure 9 shews a plan and sectional elevation of the magazine for receiving the film and its winding mechanism. Figure 10 is a perspective view of the entire apparatus. The same letters of reference denote like parts in all the figures.

The chrono-photographic apparatus is mounted upon an iron frame which supports a wood casing enclosing the whole of the mechanism and varying in dimensions according to the size of the photographs.

As shewn in Figure 10 N is a removable magazine in which is contained the spool of film whether sensitized or covered with positive pictures according as the apparatus is used for taking or projecting the scenes. The magazine has

a sliding cover N^b which is drawn out when the magazine is mounted on the apparatus. The film spool turns freely upon a spindle N^a which is mounted in the sides of the magazine N. On leaving the magazine the film passes over a guide roller L (Figure 1) and thence descends along a frame K and past the aperture *k*. The hinged shutter I in which is mounted a spring plate folds against the frame K pressing the films by means of springs contained in boxes J. On leaving frame K the film is wound upon a drum D (Figures 1 and 2) provided with pins *d* which enter perforations in the film and thence over a guide roller L^1 (Figure 1) to the magazine N^1 in which it is wound automatically. The several movements of the apparatus are produced as follows:—

The fly wheel A H (Figure 2) which is rotated by hand or by an independent motor, drives the wheel M which by means of pinion A G imparts motion to the cam grooved wheel A. The pin drum D is fast on the shaft A E of a disc B also fast on said shaft, whose sprockets *b* are successively engaged with the cam groove A; that is to say at each revolution of cam A, a sprocket *b* enters the inlet end *a* of the cam groove at same time that the preceding sprocket *b* is caused to pass out at the inclined outlet a^1 of said groove, thus producing at every revolution a forward movement of disc B and consequently of the pin drum D around which the film is carried, equal to the size of the photograph (0.02 centimetres in the present example). The in and out movement of the sprockets *b* in the groove of cam wheel A corresponding to the movement of advance of the film, occupies about one-third of the circular movement of cam A; during the other two-thirds the disc B, barrel D, and film are stationary, thus permitting either of the impression of the image or of its projection on the screen.

The shaft A D (Figure 1) which receives rotary motion from wheel M by means of pinion A G has keyed upon its opposite end a crank E which transmits reciprocating motion through connecting rod F to the plate H to which the shutter G is attached. The position of the crank E (Figure 3) upon shaft A D is rendered interchangeable by means of a screw E^a so as to enable the opening position of the sectional shutter plate G to be regulated to suit the stoppage of movement of the film. The plate G is secured to the shutter carrier H by a screw and nut G^a which is fitted to slide in a slot H^a in said carrier, so as to enable it to take a position corresponding to that of the connecting rod, according as and in proper relation to the purpose of the apparatus, whether for taking or for projecting views. When taking views, the lens C^1 is closed while the photographing lens C is uncovered by the shutter one third of the time separating two images; on the other hand for projecting, both lenses are uncovered alternately by the reciprocating movement of the shutter; it being observed that, contrary to what occurs when taking the photographs, it is the image-projecting lens C which should be uncovered for two thirds of the time separating two images and the lens C^1 during only the last third of the time. This arrangement has for object to replace, when the photographs are projected upon the screen, the dark interval corresponding to the closing of the shutter and the changing of the image, by an interval of illumination, thus suppressing sparking.

The automatic winding of the film on leaving the guide roller L^1 (Figures 1 and 2) is effected by means of the toothed wheel M^a fast with the driving wheel M and gearing with another toothed wheel A K upon the end of a shaft A^1 turning freely in bearings Z^a in which is also journalled the shaft A A of the driving and fly wheels. The shaft A^1 terminates in a split squared end with which engages the flat end of the spindle O of magazine N^1 (Figure 2). The spindle O traverses the magazine N^1 and carries upon its end a pressure spring Q and regulating nut R (Figures 2 and 9) and upon said spindle O is fitted to turn freely a sleeve O^1 upon which is fixed a disc P to which spring Q transmits rotary motion by friction, the film attached to sleeve O^1 being in this manner wound up uniformly by the action of spring Q and adjusting nut R without traction and only to the extent permitted by the feed of drum D.

Improved Apparatus for Taking and Reproducing Animated Scenes and Sounds.

The receiving magazine N^1 (Figures 1 and 2) is introduced into the casing of the apparatus through the opening S, it being guided by a T-shaped part fixed to its bottom, which is received in grooves T in the bottom of the frame. The connection of the magazine spindle O with shaft A^1 is ensured by the small spring stop S^1. The motion of the driving wheel M is imparted to a series of wheels and pinions A C which serve to divide the motion and transmit it to an exterior indicator A B which shews on a dial the length of film wound off, the indicator A B being returned to zero at the commencement of each operation, by slacking the tightening nut A F (Figures 2 and 10). Upon the rear side of the casing is an aperture having a copper lining or bushing A^1 (Figures 1, 2, and 6) in which is screwed a bearing carrying the commutator pinion which gears with the driving wheel M.

The iron framing which serves to support the before described apparatus is composed of side frames X Y (Figures 1 and 2) united at bottom by the frame Z which supports the bearing Z^2 and grooved bars T and braced together at the front by the plate W which carries the shutter G; the cross bar V which carries the guide roller L^1; the bar V^1 for supporting the delivery magazine N; and the cross bars U U^1 which serve as bearings for shaft A D.

The second part of the apparatus consists of a loud-speaking phonograph whose movement is synchronized with that of the chrono-photographic apparatus by the following arrangement of mechanism:- 29 (Figure 10) indicates a group of battery cells for the supply of the current by means of wire 30^4 to a commutator consisting of a copper ring 2 (Figure 6) screwing at A^1 on the front side of the casing of the chrono-phonographic apparatus (Figures 1 and 2). To this ring 2 (Figure 6) is fixed an ebonite sleeve 3 containing a cylinder 5, also of ebonite, which carries a copper ring 6 against which constantly bears the contact attached to binding screw 7 (Figure 5) which traverses sleeve 3. The ring 6 has an extension longitudinal of the ebonite cylinder 5 which latter is fast on the spindle 4 which passes through it and partakes in the rotary motion imparted to pinion 1 by the bevel teeth on driving wheel M (Figure 6). During this movement the extension on ring 6 comes successively in frictional contact with the contacts connected to the sockets of terminals 8^1, 8^2, 8^3, by flexible strips, so that the current which is constantly supplied at terminal 7 to ring 6 is distributed alternately to the electro-magnets 9^1, 9^2, 9^1, (Figure 4) in correspondence with the speed imparted to the driving wheel M. The electro-magnets 9^1, 9^2, 9^1, (Figures 4 and 7) are six in number and are placed in pairs around the circumference of an armature 10 bearing studs 11, eight in number, which are successively attracted by the poles 12 of the electro-magnets. The current supplied by the commutator passes alternately by the wires 30^1, 30^2, 30^3, to the electro-magnets 9^1, 9^2, 9^1, which in turn attract the contacts of armature 10 and by means of springs 14 transmit the circular motion thus obtained to the fly wheel 13 mounted on shaft 15. The object of the springs 14 is to counteract the jerks which may be produced by the successive attractions of armature 10. The current on its exit from the electro-magnets is returned to the battery by the collecting wire 30^6.

The entire electro-mechanism hereinbefore described is contained within the phonograph casing 32 (Figure 7). The shaft 15 projects up through the top of said casing and upon its upper end is keyed a bevel toothed wheel 16 which gears with two other similar wheels 17 and 18 of which wheel 17 imparts rotary motion to the phonographic cylinder 19 while the wheel 18 imparts a forward movement to the diaphragm carrier 22. The wheel 17 is fast on the axis on which is mounted the sleeve which carries the phonographic cylinder 19, the said wheel and its shaft being made removable to permit of inserting and changing the phonographic cylinders. A small pivoted latch 28 engaging in a notch in a ring 27 formed on wheel 17 serves to ensure the correct register of the cylinders at the moment of starting the apparatus. The wheel 18 is fast on a leading screw 20 with which engages a nut 23 which is connected by means of a bar to

the diaphragm carrier 22, the outer end of said screw 20 being supported in a bracket 31 (Figure 10) so that when screw 20 commences to be rotated by wheel 18, it forces the nut 23 to advance, thus carrying with it the diaphragm carrier 22. At 21 is shewn the vibrating diaphragm carrying its stylus, and 25 (Figures 8 and 10) is the sound-tube connected to the trumpet-mouth 26 to amplify the sounds emitted by the diaphragm and project them towards the audience. When an operation is finished and it is desired to return to the starting point, it is simply necessary to rock the diaphragm carrier about its guiding axis 24 (Figures 7 and 8) so as to disengage nut 23 from screw 20 and then slide the whole backwards upon the guide 24.

From the foregoing description the action of the apparatus in the two cases of taking and projecting views, will be easily understood.

For obtaining negatives, after closing the aperture in front of the idle lens C^1 and the shutter and its crank being suitably regulated for uncovering the lens C during one third of the space of time which separates two successive exposures, the film carried along by the intermittent movement of the drum D moves at a speed of 0.02 centimetres per $^1/_{20}$th of a second with a stop of two thirds of the time for the impression of the image, which occupies $^1/_{60}$th of a second. On commencing to turn the driving wheel M the commutator causes the current to pass successively to the electro-magnets, the phonographic cylinder is rotated at a speed which is absolutely synchronous with that of fly wheel A H, and, the trumpet mouth being turned towards the scene to be photographed, the phonographic cylinder records the sounds emitted at same time that the cinematograph records the corresponding movements.

For projecting the views, the two lenses being open and the shutter being regulated so as open the image lens C for two thirds and the other lens C^1 for one third only of the interval separating each change of subject, the positive film (produced in the ordinary way from the negative film previously obtained) is then placed in the apparatus, the first picture occupying the same position as the first negative, and the phonographic cylinder replaced in its support and the diaphragm carrier returned to the starting position, it is now only necessary to turn the fly wheel A H in order to impart to both apparatus an absolutely synchronous movement and thus obtain an integral and simultaneous reproduction of the movements and sounds previously recorded.

It is to be understood that the forms, dimensions, details, and materials employed in the construction of the apparatus may be varied without in any way changing the principle of the invention.

Dated this 10th day of October 1898.

A. M. & WM. CLARK,
Chartered Patent Agents, 53, Chancery Lane, London.

COMPLETE SPECIFICATION.

Improved Apparatus for Taking and Reproducing Animated Scenes and Sounds.

I, AUGUSTE BARON, of 10, Rue de l'Alma, Asnières (Seine), France, Photographer, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:–

This invention relates to a system of apparatus for recording animated scenes and sounds simultaneously and for reproducing the same simultaneously.

The apparatus consists of two distinct parts which are so combined as to form

a whole for obtaining the above result. The one part consists of a chrono-photographic apparatus for taking a series of photographs of the same moving subject at very rapid intervals, whilst the other part consists of a phonograph for recording and reproducing in a loud tone, the sounds emitted by the subject during the operation of the chrono-photographic apparatus.

The phonographic apparatus is connected to the chrono-photographic apparatus by an electrical apparatus whose movement is controlled by the driving wheel of said chrono-photographic apparatus in such manner as to cause the two apparatus to move together at the same speed, and during the reproduction by projection of the subject photographed the movements will be represented synchronously with the accompanying sounds so that the spectators will both see and hear the scenes and sounds reproduced exactly as in reality.

My invention is illustrated by way of example in the drawings accompanying my Provisional Specification in which Figure 1 is a side elevation of the chrono-photographic apparatus. Figure 2 is a plan of the chrono-photographic apparatus. Figure 3 is an elevation of the shutter mechanism. Figure 4 is a plan of the electro-motor. Figure 5 is an end elevation and Figure 6 a side elevation of the commutator. Figure 7 is a sectional elevation of the phonograph. Figure 8 is an end elevation of the frame and rocking support of the phonograph diaphragm. Figure 9 shews a plan and sectional elevation of the magazine for receiving the film and its winding mechanism. Figure 10 is a perspective view of the entire apparatus. The same letters of reference denote like parts in all the figures.

The chrono-photographic apparatus is mounted upon an iron frame which supports a wood casing enclosing the whole of the mechanism and varying in dimensions according to the size of the photographs.

As shewn in Figure 10 N is a removable magazine in which is contained the spool of film whether sensitized or covered with positive pictures according as the apparatus is used for taking or projecting the scenes. The magazine has a sliding cover N^b which is drawn out when the magazine is mounted on the apparatus. The film spool turns freely upon a spindle N^a which is mounted in the sides of the magazine N. On leaving the magazine the film passes over a guide roller L (Figure 1) and thence descends along a frame K and past the aperture *k*. The hinged shutter I in which is mounted a spring plate folds against the frame K pressing the films by means of springs contained in boxes J. On leaving frame K the film is wound upon a drum D (Figures 1 and 2) provided with pins *d* which enter perforations in the film and thence over a guide roller L^1 (Figure 1) to the magazine N^1 in which it is wound automatically.

The several movements of the apparatus are produced as follows:—The fly wheel A H (Figure 2) which is rotated by hand or by an independent motor, drives the wheel M which by means of pinion A G imparts motion to the cam grooved wheel A. The pin drum D is fast on the shaft A E of a disc B also fast on said shaft, whose sprockets *b* are successively engaged with the cam groove A, that is to say at each revolution of cam A, a sprocket *b* enters the inlet end *a* of the cam groove at same time that the preceding sprocket *b* is caused to pass out at the inclined outlet a^1 of said groove, thus producing at every revolution a forward movement of disc B and consequently of the pin drum D around which the film is carried, equal to the size of the photograph (0.02 centimetres in the present example). The in and out movement of the sprockets *b* in the groove of cam wheel A corresponding to the movement of advance of the film, occupies about one-third of the circular movement of cam A; during the other two-thirds the disc B, barrel D, and film are stationary, thus permitting either of the impression of the image or of its projection on the screen.

The shaft A D (Figure 1) which receives rotary motion from wheel M by means of pinion A G has keyed upon its opposite end a crank E which transmits reciprocating motion through connecting rod F to the plate H to which the shutter G is attached. The position of the crank E (Figure 3) upon shaft A D is rendered interchangeable by means of a screw adjustment E^a so as to enable the

opening position of the sectional shutter plate G to be regulated to suit the stoppage of movement of the film. The plate G is secured to the shutter carrier H by a screw and nut G' which is fitted to slide in a slot H" in said carrier, so as to enable it to take a position corresponding to that of the connecting rod, according as and in proper relation to the purpose of the apparatus, whether for taking or for projecting views. When taking views, the lens C¹ is closed while the photographing lens C is uncovered by the shutter one third of the time separating two images; on the other hand for projecting, both lenses are uncovered alternately by the reciprocating movement of the shutter, it being observed that, it is the image-projecting lens C which should be uncovered for two thirds of the time separating two images and the lens C¹ (which is only used when projecting) during only the last third of the time. This arrangement has for object to replace, when the photographs are projected upon the screen, the dark interval corresponding to the closing of the shutter and the changing of the image, by an interval of illumination, thus suppressing sparking.

The automatic winding of the film on leaving the guide roller L¹ (Figures 1 and 2) is effected by means of the toothed wheel M* fast with the driving wheel M and gearing with another toothed wheel A K upon the end of a shaft A' turning freely in bearings Z* in which is also journalled the shaft A A of the driving and fly wheels. The shaft A' terminates in a split squared end with which engages the flat end of the spindle O of magazine N¹ (Figure 2). The spindle O traverses the magazine N¹ and carries upon its end a pressure spring Q and regulating nut R (Figures 2 and 9) and upon said spindle O is fitted to turn freely a sleeve O¹ upon which is fixed a disc P to which spring Q transmits rotary motion by friction, the film attached to sleeve O¹ being in this manner wound up uniformly by the action of spring Q and adjusting nut R without traction and only to the extent permitted by the feed of drum D.

The receiving magazine N¹ (Figures 1 and 2) is introduced into the casing of the apparatus through the opening S, it being guided by a T-shaped part fixed to its bottom, which is received in grooves T in the bottom of the frame. The connection of the magazine spindle O with shaft A' is ensured by the small spring stop S*. The motion of the driving wheel M is imparted to a series of wheels and pinions A C which serve to divide the motion and transmit it to an exterior indicator A B which shews on a dial the length of film wound off, the indicator A B being returned to zero at the commencement of each operation, by slacking the tightening nut A F (Figures 2 and 10). Upon the rear side of the casing is an aperture having a copper lining or bushing A¹ (Figures 1, 2, and 6) in which is screwed a bearing carrying the commutator pinion which gears with the driving wheel M.

The iron framing which serves to support the before described apparatus is composed of side frames X Y (Figures 1 and 2) united at bottom by the frame Z which supports the bearing Z* and grooved bars T and braced together at the front by the plate W which carries the shutter G; the cross bar V which carries the guide roller L¹; the bar V¹ for supporting the delivery magazine N; and the cross bars U U¹ which serve as bearings for shaft A D.

The second part of the apparatus consists of a loud-speaking phonograph whose movement is synchronised with that of the chrono-photographic apparatus by the following arrangement of mechanisms:—29 (Figure 10) indicates a group of battery cells for the supply of the current by means of wire 30* to a commutator consisting of a copper ring 2 (Figure 6) screwing at A¹ on the front side of the casing of the chrono-photographic apparatus (Figures 1 and 2). To this ring 2 (Figure 6) is fixed an ebonite sleeve 3 containing a cylinder 5, also of ebonite, which carries a copper ring 6 against which constantly bears the contact attached to binding screw 7 (Figure 5) which traverses sleeve 3. The ring 6 has an extension longitudinal of the ebonite cylinder 5 which latter is fast on the spindle 4 which passes through it and partakes in the rotary motion imparted to pinion I by the bevel teeth on driving wheel M (Figure 6). During

this movement the extension on ring 6 comes successively in frictional contact with the contacts connected to the sockets of terminals 8^1, 8^2, 8^3, by flexible strips, so that the current which is constantly supplied at terminal 7 to ring 6 is distributed alternately to the electro-magnets 9^1, 9^2, 9^3, (Figure 4) in correspondence with the speed imparted to the driving wheel M. The electro-magnets 9^1, 9^2, 9^3, (Figures 4 and 7) are six in number and are placed in pairs around the circumference of an armature 10 bearing studs 11, eight in number, which are successively attracted by the poles 12 of the electro-magnets. The current supplied by the commutator passes alternately by the wires 30^1, 30^2, 30^3, to the electro-magnets 9^1, 9^2, 9^3, which in turn attract the contacts of armature 10 and by means of springs 14 transmit the circular motion thus obtained to the fly wheel 13 mounted on shaft 15. The object of the springs 14 is to counteract the jerks which may be produced by the successive attractions of armature 10. The current on its exit from the electro-magnets is returned to the battery by the collecting wire 30^4.

The entire electric-mechanism hereinbefore described is contained within the phonograph casing 32 (Figure 7). The shaft 15 projects up through the top of said casing and upon its upper end is keyed a bevel toothed wheel 16 which gears with two other similar wheels 17 and 18 of which wheel 17 imparts rotary motion to the phonographic cylinder 19 while the wheel 18 imparts a forward movement to the diaphragm carrier 22. The wheel 17 is fast on the axis on which is mounted the sleeve which carries the phonographic cylinder 19, the said wheel and its shaft being made removable to permit of inserting and changing the phonographic cylinders. A small pivoted latch 28 engaging in a notch in a ring 27 formed on wheel 17 serves to ensure the correct register of the cylinder at the moment of starting the apparatus. The wheel 18 is fast on a leading screw 20 with which engages a nut 23 which is connected by means of a bar to the diaphragm carrier 22, the outer end of said screw 20 being supported in a bracket 31 (Figure 10) so that when screw 20 commences to be rotated by wheel 18, it forces the nut 23 to advance, thus carrying with it the diaphragm carrier 22. At 21 is shewn the vibrating diaphragm carrying its stylus, and 25 (Figures 8 and 10) is the sound-tube connected to the trumpet-mouth 26 to amplify the sounds emitted by the diaphragm and project them towards the audience. When an operation is finished and it is desired to return to the starting point, it is simply necessary to rock the diaphragm carrier about its guiding axis 24 (Figures 7 and 8) so as to disengage nut 23 from screw 20 and then slide the whole backwards upon the guide 24.

From the foregoing description the action of the apparatus in the two cases of taking and projecting views, will be easily understood.

For obtaining negatives, after closing the aperture in front of the idle lens C^1 and the shutter and its crank being suitably regulated for uncovering the lens C during one third of the space of time which separates two successive exposures, the film carried along by the intermittent movement of the drum D moves at a speed of 0.02 centimetres per $\frac{1}{25}$th of a second with a stop of two thirds of the time for the impression of the image, which occupies $\frac{1}{75}$th of a second. On commencing to turn the driving wheel M the commutator causes the current to pass successively to the electro-magnets, the phonographic cylinder is rotated at a speed which is absolutely synchronous with that of fly wheel A H, and, the trumpet mouth being turned towards the scene to be photographed, the phonographic cylinder records the sounds emitted at same time that the cinematograph records the corresponding movements.

For projecting the views, the two lenses being open and the shutter being regulated so as open the image lens C for two thirds and the other lens C^1 for one third only of the interval separating each change of subject, the positive film (produced in the ordinary way from the negative film previously obtained) is then placed in the apparatus, the first picture occupying the same position as the first negative, and the phonographic cylinder replaced in its support and the

diaphragm carrier returned to the starting position; it is now only necessary to turn the fly wheel A H in order to impart to both apparatus an absolutely synchronous movement and thus obtain an integral and simultaneous reproduction of the movements and sounds previously recorded.

It is to be understood that the forms, dimensions, details, and materials employed in the construction of the apparatus may be varied without in any way changing the principle of the invention.

Having now particularly described and ascertained the nature of the said invention and in what manner the same is to be performed, I declare that what I claim is:—

The improved apparatus for taking and reproducing animated scenes and sounds simultaneously combined and arranged substantially as hereinbefore described and illustrated in the drawings, characterized:—

1. By the combination with the chrono-photographic apparatus, of two lenses for the projection of the photographs, one of which is closed while the other is open, by means of a reciprocating shutter, for the purpose of suppressing the dark interval on the screen which separates each change of image and thus obviating sparking.

2. By the means for automatically winding the film in a magazine by means of a spring in frictional contact with a disc whose movement is capable of being arrested by the resistance of the film.

3. By the automatic index finger for constantly indicating the length of film used;

4. By the commutator operated by the movement of the driving wheel of the chrono-photographic apparatus and permitting of the passage of the current only in accordance with the movement of the driving wheel;

5. By the system of electro-motor comprising several groups of electro-magnets which successively attract the studs of the armature in such manner that each of said groups attracts and retains the studs until the moment when the current is cut off by the action of the commutator and passed to the following group which in its turn attracts and retains the next nearest studs; the rotation of the armature being thus absolutely dependent on the movement of a commutator which distributes the current to the groups of electro-magnets of the motor and the motion of said armature being transmitted to a phonographic cylinder.

6. By the equalization of the motion produced by the armature of the electro-motor by means of a fly wheel connected thereto by means of springs so as to prevent the transmission of the jerks of the armature to the phonographic cylinder.

7. By the reciprocating shutter operating in such manner that the movements of opening and closing shall occur when the connecting rod is moving most rapidly.

Dated this 5th day of July 1899.

A. M. & WM. CLARK,
Chartered Patent Agents, 53, Chancery Lane, London.

Redhill: Printed for Her Majesty's Stationery Office, by Malcomson & Co., Ltd.—1899.

FIG. 8.

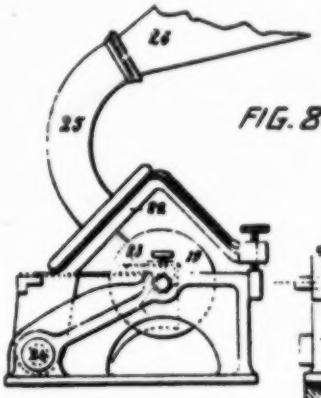


FIG. 7.

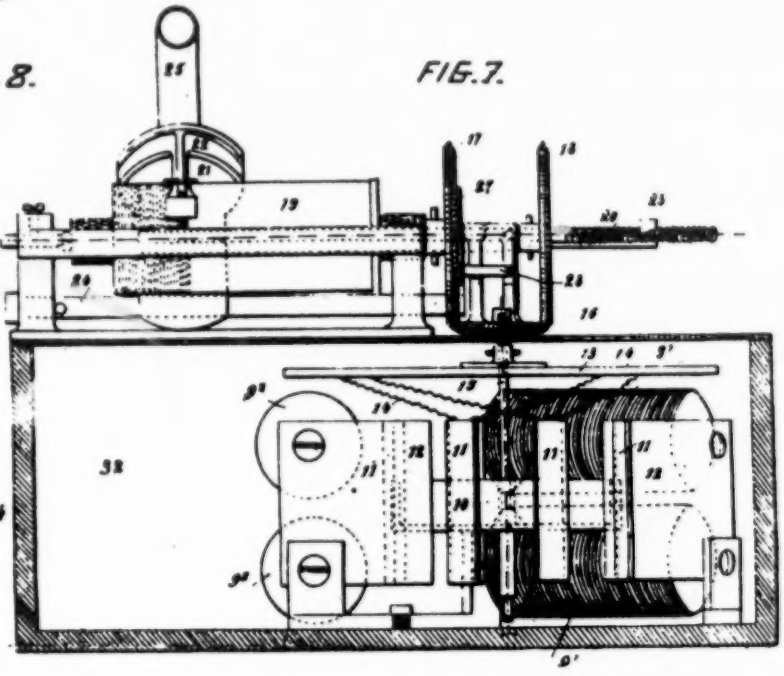


FIG. 6.

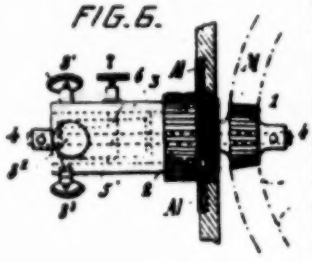


FIG. 4.

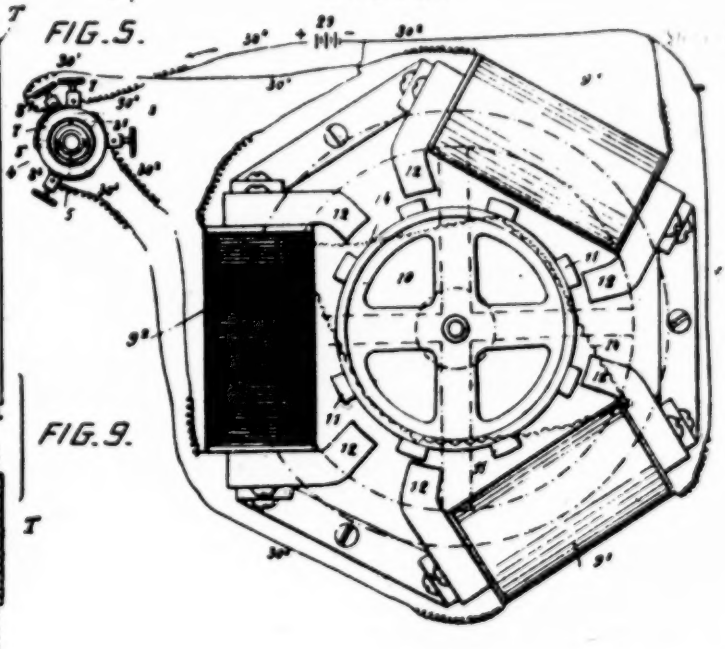


FIG. 5.

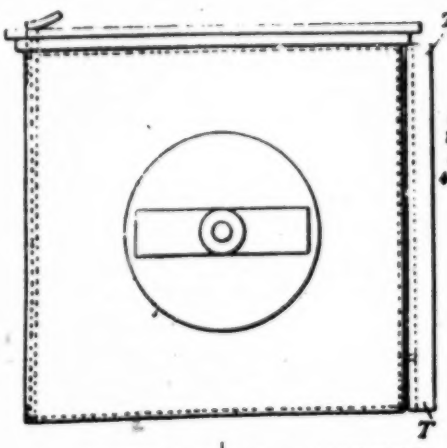


FIG. 9.

A.D. 1898. Oct. 11. N° 21,371.
BARON'S Patented Oscillator.

FIG. 9.

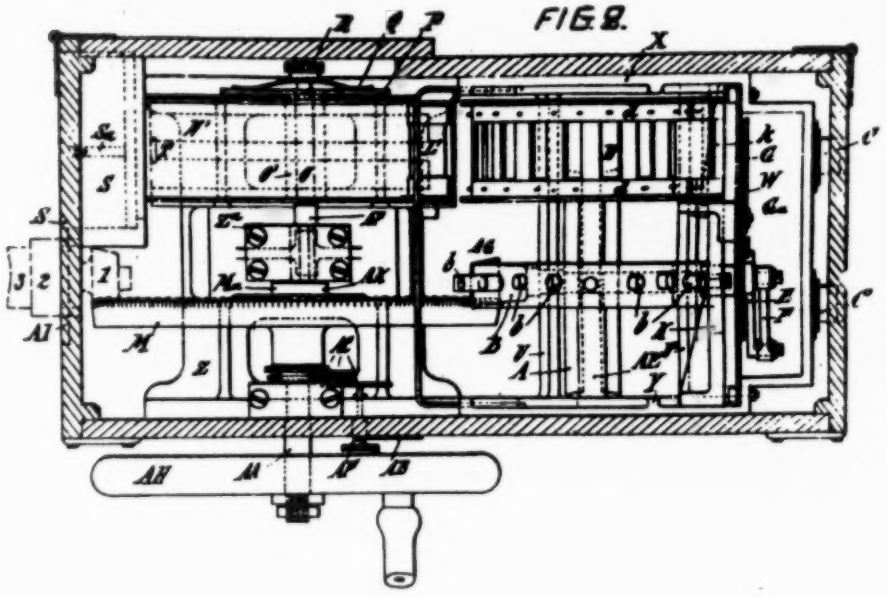
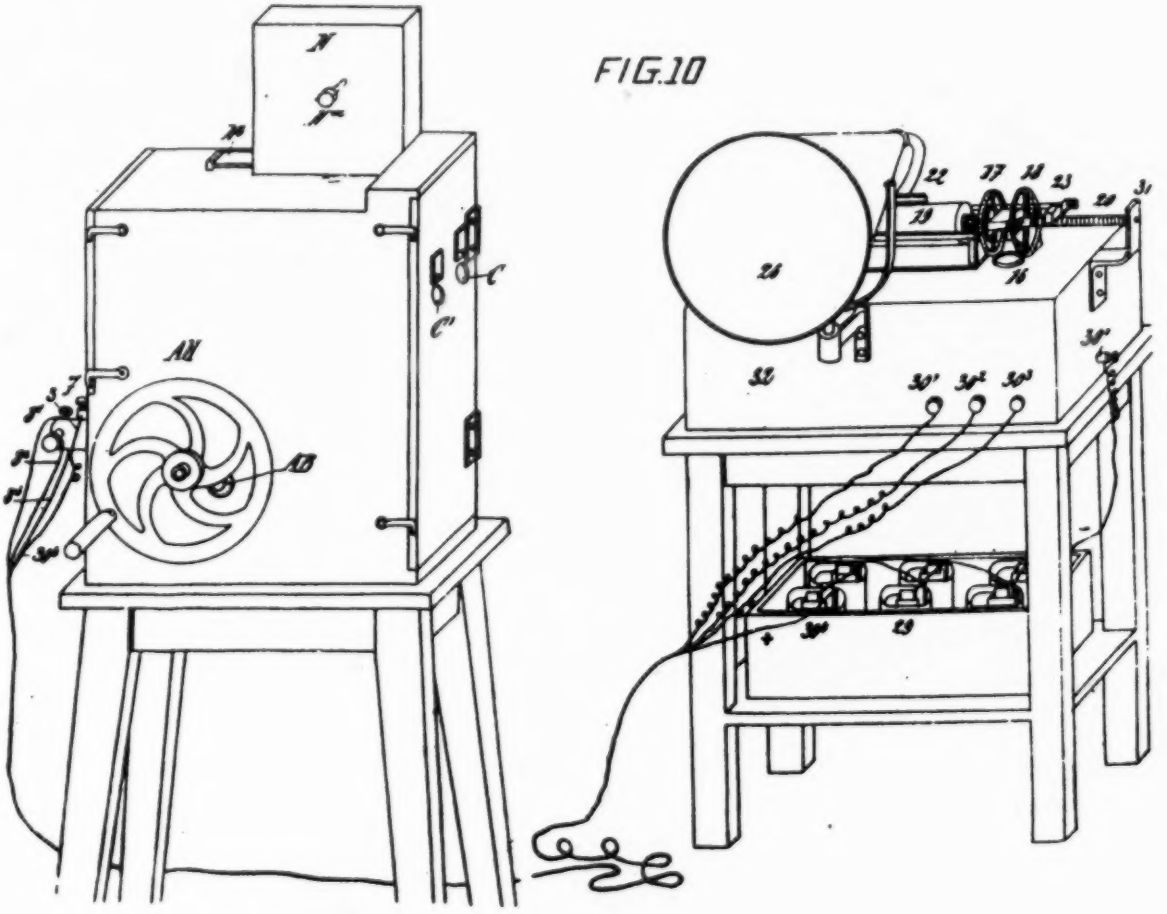


FIG. 10



A.D. 1898. Oct. 11 21,371.
BARON'S Provisional ... specification.

1834

FIG.1

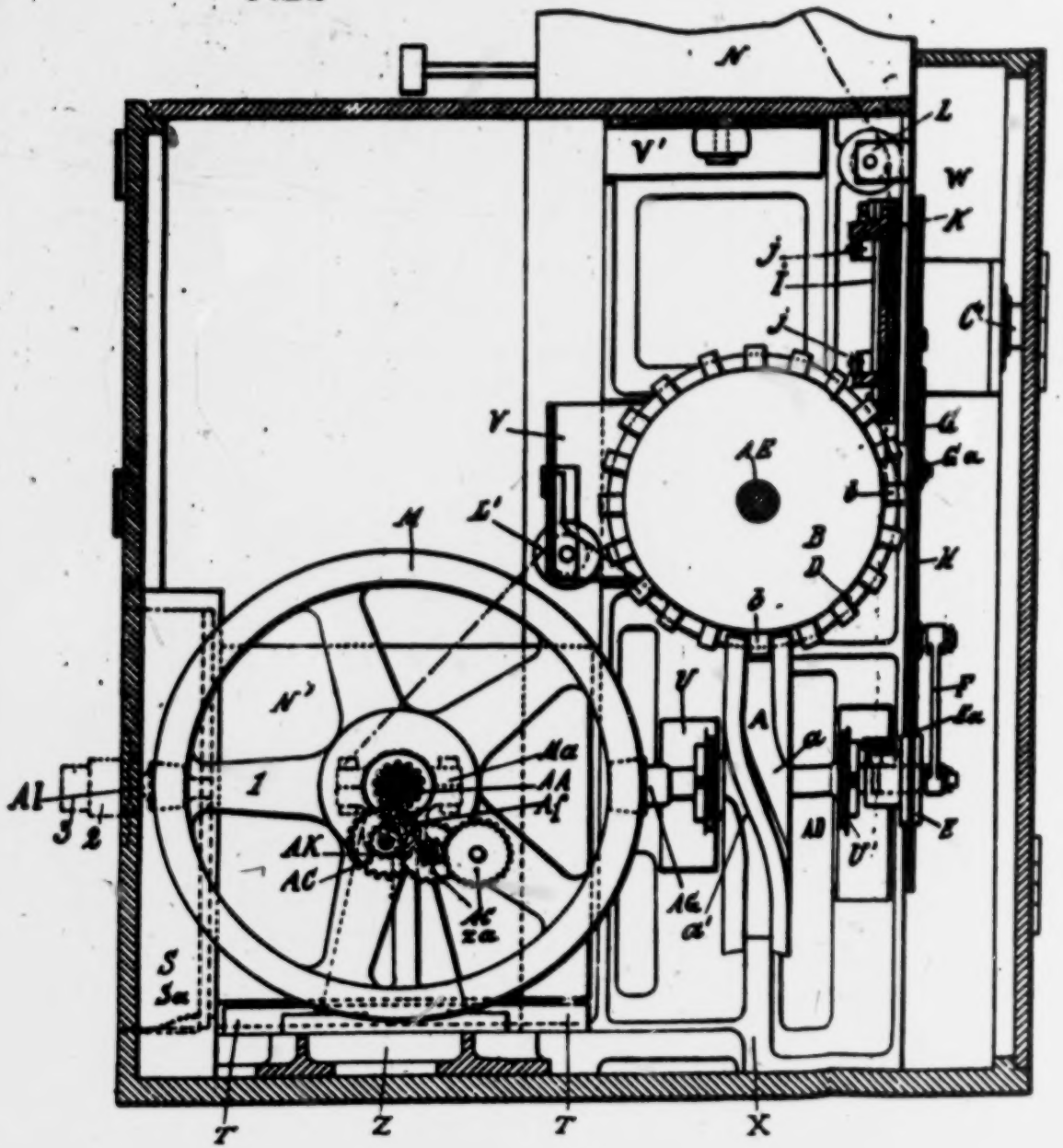
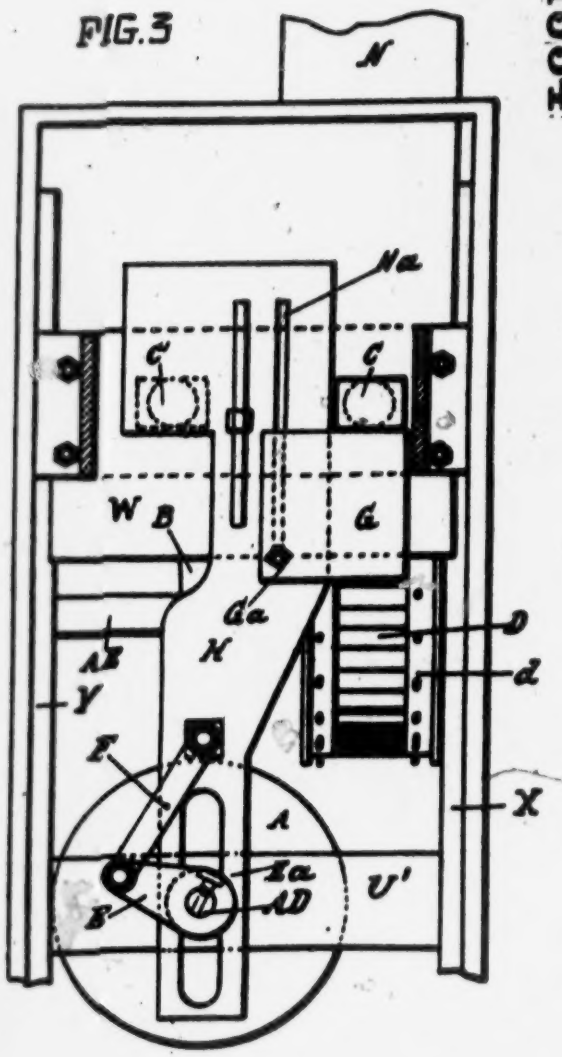


FIG.3



N° 24,546 A.D. 1902

Date of Application, 10th Nov., 1902

Complete Specification Left, 6th Aug., 1903—Accepted, 1st Oct., 1903

PROVISIONAL SPECIFICATION.

An Improved Phonograph

I, WILLIAM DU BOIS DUDDELL, Electrical Engineer, of 47 Hans Place Chelsea in the County of London, do hereby declare the nature of this invention to be as follows:—

To carry out my invention I take a microphone or other apparatus for converting sounds into a phonic electric current. I record by means of an oscillograph or similar apparatus the varying current, or the variable part thereof, or a current derived from it by means of transformers, condensers, inductive resistances, or other well known apparatus. I make this record on a moving film, or paper, or other suitable photographic material in such a way that the width at any instant of the part being exposed, or not exposed as the case may be, is determined by the deflection of the oscillograph at that instant.

One simple way of doing this is to arrange the optical system so that the moving spot of light, whose deflection is determined by the current, has a very narrow rectangular form, like a line of light, the long side of the spot being parallel to its direction of motion and at right angles to the direction of motion of the photographic material on which the record is being made. The length of the spot should be equal to, or greater than, the width of the record required. This spot of light is so adjusted that in its mean position one of its ends is approximately central in the width of the record, so that one half of the record is illuminated and the other half not; the movement of the spot varies the proportions of the illuminated and non-illuminated parts.

When the usual photographic operations are completed I obtain a record consisting, at each point along its length, of a dark and a light part in varying proportions representing the sounds.

To reconvert this record into sounds again I pass through it a beam of light and cause the record to move at about the same speed as when it was made. Owing to the varying proportions of the light and dark parts along the record the light passing through it varies in such a way as to correspond with the sounds the record represents.

The beam of light after passing through the record illaminates a selenium cell or other apparatus sensitive to light and its variaitons are reconverted into sounds as in the well known Graham bell photophone.

From one original record I can make any number of copies by photography, lithography, and other well known means.

Dated this the Eighth day of November 1902.

WILLIAM DUDDELL.

COMPLETE SPECIFICATION.

An Improved Phonograph

I, WILLIAM DU BOIS DUDDELL, Electrical Engineer, of 47 Hans Place Chelsea in the County of London, do hereby declare the nature of this invention

and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

To carry out my invention, I take a microphone or other apparatus for converting sounds into a phonic electric current. I record by means of an oscillograph or similar apparatus this varying current, or the variable part thereof, or a current derived from it by means of transformers condensers, inductive resistances, or other well known apparatus. I make this record on a moving film, or paper, or other suitable photographic material in such a way that the width at any instant of the part being exposed, or not exposed, as the case may be is determined by the deflection of the oscillograph at that instant.

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When the usual photographic operations are completed I obtain a record consisting, at each point along its length of a dark and a light part in varying proportions representing the sounds.

To reconvert this record into sounds again I pass through it a beam of light and cause the record to move at about the same speed as when it was made.

Owing to the varying proportions of the light and dark parts along the record the light passing through it varies in such a way as to correspond with the sounds the record represents.

The beam of light after passing through the record illuminates a selenium cell or other apparatus sensitive to light and its variations are reconverted into sounds as in the well-known Graham bell photophone.

From one original record I can make any number of copies by photography, lithography and other well known means.

I will now proceed to more particularly describe with reference to the accompanying drawing, one way of carrying out my invention, though I do not limit myself to this way.

Figures 1, 2, 3, 4, and 5 represent different arrangements of the electric connections which I can use to convert the sounds it is required to record into phonic electric currents through the oscillograph. Figure 6 is a diagramatic view of a recording apparatus. Fig. 7 is a reproducing apparatus and Fig. 8 represents the electric circuits used in reproducing the sounds. In all the figures the same letters denote similar things.

In Figure 1. M. is a microphone or microphones before which the sounds to be recorded are made. B is a battery, or other source of electric current, in series with the microphone and O is the circuit of the oscillograph, shown as a bifilar oscillograph though I can use other types. With this arrangement the whole of the microphone current passes through the oscillograph. The current through a microphone may be considered to consist of two parts, a constant part and a varying part whose changes correspond to the sound waves. It is the variations of this latter part of the current which I require to record in order to carry out my invention or else a co-related current derived from it.

When using the connections Figure 1. I find it preferable to work the oscillograph to a false zero and only record the variations in the current. I can also divert the greater part of the constant part of the current from passing through the oscillograph by using the connections shewn in Figure 2. in which R is a shunt resistance and B' a second battery connected so as to oppose the flow

of the constant part of the current through the oscillograph. If the shunt R Figure 2 is constructed with a low resistance compared to that of the oscillograph and a high self induction I find that the battery B^1 may be omitted as the greater part of the constant part of the microphone current will pass through the inductive shunt and the varying part will pass through the oscillograph. With this latter connection I can completely prevent the constant part of the microphone current from flowing through the oscillograph by introducing a condenser as shewn at F in Figure 3. I can use this inductive shunt if suitably wound as an auto-transformer as shewn in Figure 4 in order to raise or lower the available voltage to send the varying current through the oscillograph, as may be required, according to the impedance and sensibility of the oscillograph used. With this connection I also sometimes use a condenser or back electromotive force between the auto-transformer and the oscillograph. In many cases I prefer to use the arrangement shown in Figure 5, a transformer T is connected with its primary in series with the microphone and its secondary is connected to the oscillograph. The ratio of the transformer is so chosen with regard to the microphone circuit and the oscillograph circuit as to give a sufficiently large current through the latter to produce the required amplitude for the record. In all the above arrangements I sometimes used shunt and series resistances or inductances or condensers to regulate the flow of the currents in the well known ways.

One arrangement I can employ to record the movements of the oscillograph mirror caused by the phonic currents is shewn in Fig. 6 in which *m* is the mirror of the oscillograph on which the light from an intense source A is converged by means of a lens L through a diaphragm *d*. The reflected beam of light falls on the sensitive film or other protographic material *f* at *e*. A cylindrical lens with its axis parallel to the direction of motion of the reflected beam is placed at C between the oscillograph and the film and nearer the latter, the focus of the cylindrical lens is so chosen that the point *e* and the mirror *m* are at its conjugate foci so as to produce a fine bright line of light on the sensitive material the length of which is parallel to its direction of motion when the oscillograph mirror *m* is deflected by a current passing through the instrument. The diaphragm *d*, having a rectangular aperture, is so chosen that the length of this line of light is at least equal to the width of the record it is required to produce.

I can also introduce other diaphragms and lenses into the above optical system so as to make this line of light as fine and bright and as sharply defined as possible. Thus for instance I can introduce a very fine slit d^1 placed at *e* and cut off the fringes from the line of light due to imperfections in the acromatism or other corrections of the lenses.

In what follows I will for the sake of clearness assume that the photographic material used is a long sensitive film or paper.

When no sounds are being produced and the oscillograph mirror is at rest one end of the line of light should be approximately central in the width of the film. When the mirror is deflected in one direction or the other the line of light will move more or less completely across the surface of the film exposing a greater or less fraction of the width. When the mirror is at rest about one half the width will be exposed and the other half not exposed. If a current flows through the oscillograph in one direction then a greater fraction of the whole width of the film will be exposed, the excess above the one half depending on the value of the current. If the current flows through the oscillograph in the opposite direction a less fraction than one half the width will be exposed, the deficit depending on the value of the current.

When the line of light is in movement due to the varying currents through the oscillograph I cause the sensitive photographic film to travel in a direction at right angles to the direction of motion of the line of light, by winding the film steadily and uniformly from one of the drums D, D^1 to the other by any

of the well known means. The speed at which the film requires to travel depends, among other things, on the perfection of the definition and fineness of the line of light and on the reproducing apparatus. The speed should be sufficiently high to resolve, in the record, the quick movements of the line of light corresponding to the highest note or sound it is required to record. From the point of view of cost of photographic material is is advisable to use a slow speed. I find that a linear speed of about three feet per second gives good results though I do not limit myself to this speed.

Of course the whole of the film is enclosed in a light tight box and protected from exposure to any other actinic light than line of light reflected from the oscillograph mirror. The film is kept running during the whole time a record is being made and is subsequently subjected to the usual photographic operations of developing and fixing.

The finished film should consist lengthwise, of two parts differing greatly in opacity, the one of which is practically opaque and the other transparent. The line of separation between these two parts will be a serrated line corresponding to the variations in the current through the oscillograph and consequently to the sound waves.

This film may now be used as a record from which the sounds can be reproduced as described below, or prints or copies may be made from it either by photography or in any of the other known ways and these prints or copies may either be exactly like the original or may have the opaque part of the original reproduced as a transparent part and the transparent part reproduced as an opaque part. Further when copying the film the difference in opacity between the two parts of the record may, with advantage be increased in the well known ways.

In order to reproduce at will the original sounds I employ the apparatus shewn diagramatically in Figure 7. The light from the source A is concentrated by means of the condenser L and the cylindrical lens C into an intense line of light which passes through the record f at e.

I sometimes find it advantageous to employ a fine slit at d^1 to improve the definition and firmness of the line of light.

A selenium cell or other photo-electric apparatus is placed at S and is suitably enclosed so that it is only illuminated by the light which passes through the record.

The record is caused to travel by winding it steadily from one of the drums D, D^1 to the other, at approximately the same speed as was used in making the record, this causes the illumination of the selenium cell to vary in a manner corresponding to the relative widths of the opaque and clear parts at each point of the record; and consequently corresponding to the movements of the oscillograph mirror which was originally employed to make the record and to the original sound waves. I connect in series with the selenium cell a battery B Fig. 8 and one or more telephone receivers t t^1 so that when the resistance of the selenium cell varies due to changes in the illumination the current through the telephone receivers also varies causing them to reproduce faithfully the original sounds.

Instead of connecting the telephone receivers direct to the selenium cell and battery I sometimes employ a transformer between the selenium cell circuit and the receivers.

When using a selenium cell whose mean resistance is high I find it advisable to employ telephone receivers having a considerable number of turns in their windings.

In the place of the selenium I can also use other photo electric apparatus, the electrical connections of the reproducing circuit being suitably modified.

Although I have described the recording and reproducing apparatus as separate I can also make one apparatus serve for both as many of the essential parts are the same in both.

I have described above my invention as carried out when using a long length of photographic film or paper which is wound from one drum to another. I can also use a flat disc of photographic material and make the record in the form of a spiral on it, or I can wrap photographic material round a cylinder and make a helical record on it which can be afterwards unwrapped and laid flat for development or storage.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed I declare that what I claim is :

(1) The use of an oscillograph to produce a record consisting of two parts differing greatly in opacity, the line of demarcation between the two representing the variations of a microphonic, or other phonic current, or of a current derived from it.

(2) The use of the above record or of a copy of it or of a copy of it in which the opaque part is copied as clear and the clear part is copied as opaque in conjunction with a source of light, a photo electric apparatus & a telephone receiver or receivers with or without a transformer to reproduce the sounds.

(3) The use of a bifilar oscillograph to produce a photographic record consisting of two parts differing greatly in opacity, the line of demarcation between the two representing the variations of the current derived from a microphone current by means of a transformer.

(4) The use of the above record or of a copy of it or of a copy of it in which the opaque part is copied as clear and the clear part is copied as opaque in conjunction with a source of light and a selenium cell in series with a battery and one or more telephone receivers with or without a transformer, to reproduce the sounds.

(5) The combination of a diaphragm and lens between the source of light and the oscillograph with a cylindrical lens between the oscillograph and the sensitive surface so as to produce a fine intense line of light which moves parallel to its length when the oscillograph is deflected and whose motion combined with that of the sensitive surface produces the two part photographic record substantially as hereinbefore described.

(6) The separation of the variable part from the constant part of the phonic current for the purposes of my invention by means of the electric circuits shown diagrammatically in Figures 2, 3, 4, and 5, substantially as hereinbefore described.

Dated the Sixth day of August 1903.

WILLIAM DUDDELL.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1903.

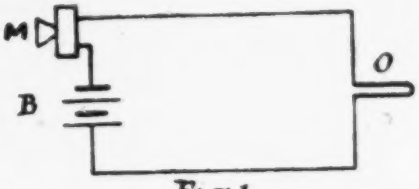

Fig 1

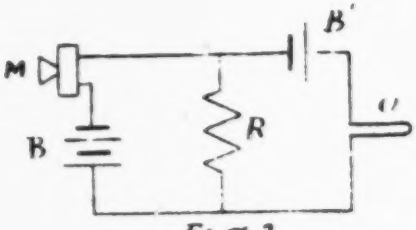

Fig. 2.

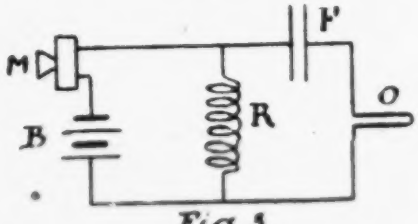

Fig. 3.

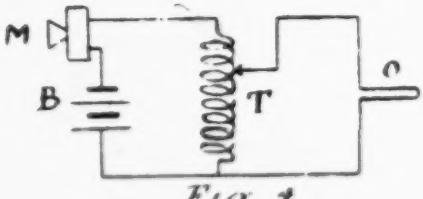

Fig. 4.

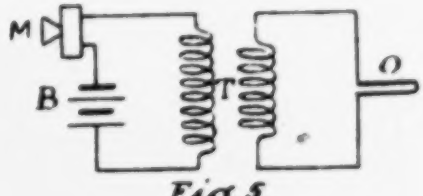

Fig. 5.

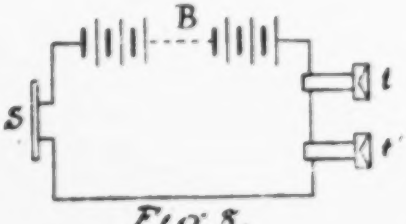

Fig. 8.

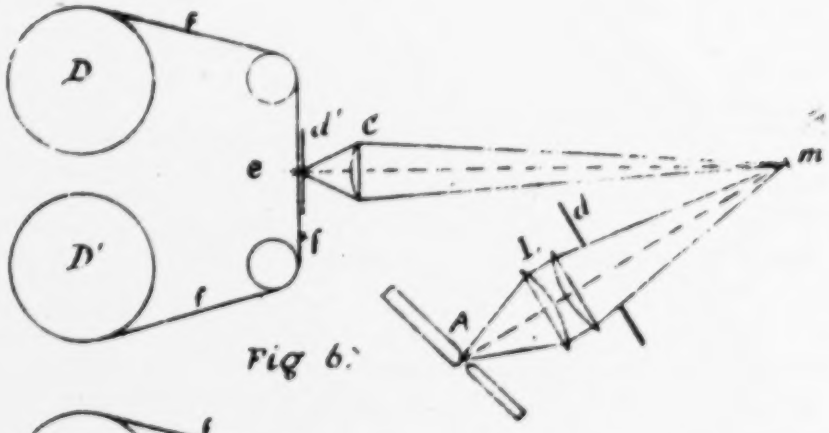

Fig 6.

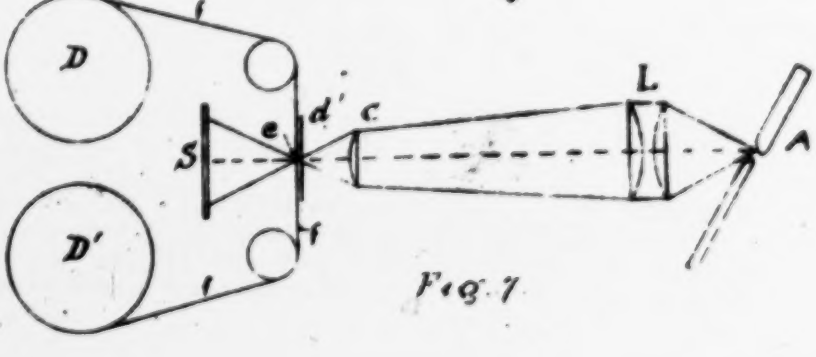

Fig. 7

[This Drawing is a reproduction of the Original on a reduced scale]

N° 15,333 A.D. 1912

Date of Application, 1st July, 1912—Accepted, 3rd Apr., 1913

COMPLETE SPECIFICATION.

Improvements in and relating to Gearing for the Transmission of Rotary Motion.

We, FREDERICK HENRY ROYCE, of Nightingale Road, Osmaston Road, Derby, in the County of Derby, Engineer, and ROLLS-ROYCE LIMITED, of Nightingale Road, in the Town & County aforesaid, Motor Car Manufacturers, do hereby declare the nature of this invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to gearing for the transmission of rotary motion, and has for its object the elimination of certain forms of irregular angular velocity and/or torque in the driven element of such gearing.

According to the present invention, a spring or elastic buffer drive and a spring-controlled frictional damper are interposed between the driving and driven elements of the gearing, the construction and arrangement of said devices having the following characteristics:—(1) That the spring or elastic buffer drive can alone transmit the whole of the drive; (2) That the spring-controlled frictional damper cannot efficiently transmit the drive; and (3) That the two devices function independently, that is to say, each performs the function it is designed to perform independently of the other.

In the transmission of rotary motion from prime movers, rotary vibrations are frequently set up in the transmission shafts or parts when such shafts or parts have a natural elasticity in a rotary direction. These vibrations arise from the variations in angular velocity or torque which occur during each revolution and are found more particularly when the driven part includes a member of appreciable fly-wheel effect. For the purpose of eliminating or diminishing these variations in angular velocity or torque, a spring or elastic buffer drive has sometimes been employed, but in many cases the effect of this is that the relative rotary movement which consequently occurs between the driving and driven members of the transmission system develops into objectionable periodic or synchronous rotary vibrations.

We are aware that frictional dampers have already been employed in transmission gears for the purpose of overcoming periodic or synchronous rotary vibrations and also that transmission gears have been proposed in which both a spring or elastic drive and a frictional coupling have been employed, but in said construction the friction coupling is not employed for deadening or stopping periodic vibrations but for the purpose of transmitting the drive equally to two driven members and both parts have to transmit the whole of the drive, which is not the case in the present invention.

By our construction the transference of irregularities in angular velocity and/or torque between said members is completely or partially prevented, and any slight remaining irregularities of angular velocity and/or torque are prevented from developing into periodic or synchronous rotary vibrations.

In order that our invention may be fully understood, we will more particularly describe it, making reference to the accompanying drawings, which illustrate by way of example two applications of the invention, and in which:—Fig. 1,

[*Price 8d.*]

Sheet No. 1, is a view in transverse section, and Fig. 2, Sheet No. 1, is a view in plan—half in section—of a mechanism for transmitting rotary movement from a shaft to a gear wheel; Fig. 1 being a half section on line *v v* and a half section on line *w w* Fig. 2, and Fig. 2 being a half section on line *x x* Fig. 1.

Figs. 3 & 4, Sheet No. 2, are similar views of a mechanism for transmitting rotary movement from one shaft to another; Fig. 3 being a half section on line *v v* and a half section on line *w w* Fig. 4, and Fig. 4 being a half section on line *x—x* of Fig. 3.

Throughout the views similar parts are marked with like letters of reference.

Referring to Figs. 1 & 2, the shaft *a* has four outwardly projecting radial lugs a^1 which are preferably equally spaced. The gear wheel *b* from or to which is transmitted the rotary movement of the shaft *a* has its boss b^3 made of annular box-like form and has its ends closed by plates *p* and p^1. This boss carries within it four lugs b^1 which project inwardly and alternate with the lugs a^1. Interposed between the lugs a^1 and b^1 are spring or elastic buffers *e* which are stiff enough to transmit the whole of the drive. Mounted on the shaft *a* by means of castellations a^2 formed on its external circumference are a series of friction discs *d*, and mounted in a similar manner on castellations b^2 formed on the internal circumference of the boss b^3 of the wheel *b* are a series of friction discs *c* which alternate with the discs *d*. These friction discs are kept in contact with one another by means of a spring *f* which operates between a specially shaped end friction disc f^1 and the end cover plate *p*. The strength of the spring *f* is such that it cannot transmit the drive so that the device can only function as a vibration damper. The other end friction disc f^2 is suitably strengthened and contacts one side of the lugs b^1 and the other cover plate p^1 contacts the other side of the lugs b^1. The lugs a^1 are made slightly narrower than the lugs b^1 so that they are free to move in a rotary direction independent of the gear wheel *b* and its box-like boss.

The mechanism is operative in either direction, that is to say, the rotary motion can be transmitted from the shaft *a* to the gear wheel *b* or *vice versa*, the drive being taken through the lugs a^1 and b^1 and through the spring or elastic buffers *e*, the said spring or elastic buffers allowing the driven member to move relatively to the driving member in a rotary direction about its axis within certain limits, but these relative rotary movements of the driven member are prevented from developing into objectionable rotary vibrations by means of the damping action of the friction discs *d* and *c*.

In the construction shown in Figs. 3 & 4 the lugs b^1 are carried by an annular member b^3 mounted on a flange s^1 fixed on or forming part of the shaft *s* from or to which is transmitted the rotary movement of the shaft *a*. Instead of employing a spring *f* such as is shown in Fig. 2 for exerting pressure between the friction discs, a series of springs f^3 as shown in Fig. 4 may be employed.

Having now particularly described and ascertained the nature of our said invention, and in what manner the same is to be performed, we declare that what we claim is:—

1. In gearing for transmitting rotary motion from one element to another, the combination of a spring or elastic buffer drive and a spring-controlled frictional damper interposed between the driving and driven elements of the said gearing, the construction and arrangement of said devices having the characteristics hereinbefore specified.

2. In a gearing for transmitting rotary motion, combination of a driving member having a series of radially arranged lugs or projections, a driven member having a series of radially arranged lugs or projections arranged to alternate with the lugs or projections carried by the driving member, springs or elastic buffers located and acting between the said two series of lugs or projections, two series of alternately arranged friction discs connected respectively to the driving

and driven members, and spring-controlled means for creating and preserving frictional contact between said discs.

3. In a gearing for transmitting rotary motion, the combination of a transmitting member, an annular member carried by said transmitting member, a series of inwardly projecting lugs carried by said annular member, a second transmitting member, a series of outwardly projecting lugs carried by said second transmitting member, springs or elastic buffers interposed between the said two series of lugs, a series of friction discs carried by each of the transmitting members, those carried by one alternating with those carried by the other, and one or more springs operating to keep the two series of discs in frictional contact, as and for the purpose set forth.

4. The improved gearing for transmitting rotary motion, substantially as herein described and illustrated in the accompanying drawings.

Dated this 1st day of July, 1912.

PHILLIPSS,
Chartered Patent Agents,
70, Chancery Lane, London, W.C.,
Agents for the Applicants.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1913.

A.D 1912, July 1. No. 15,333.

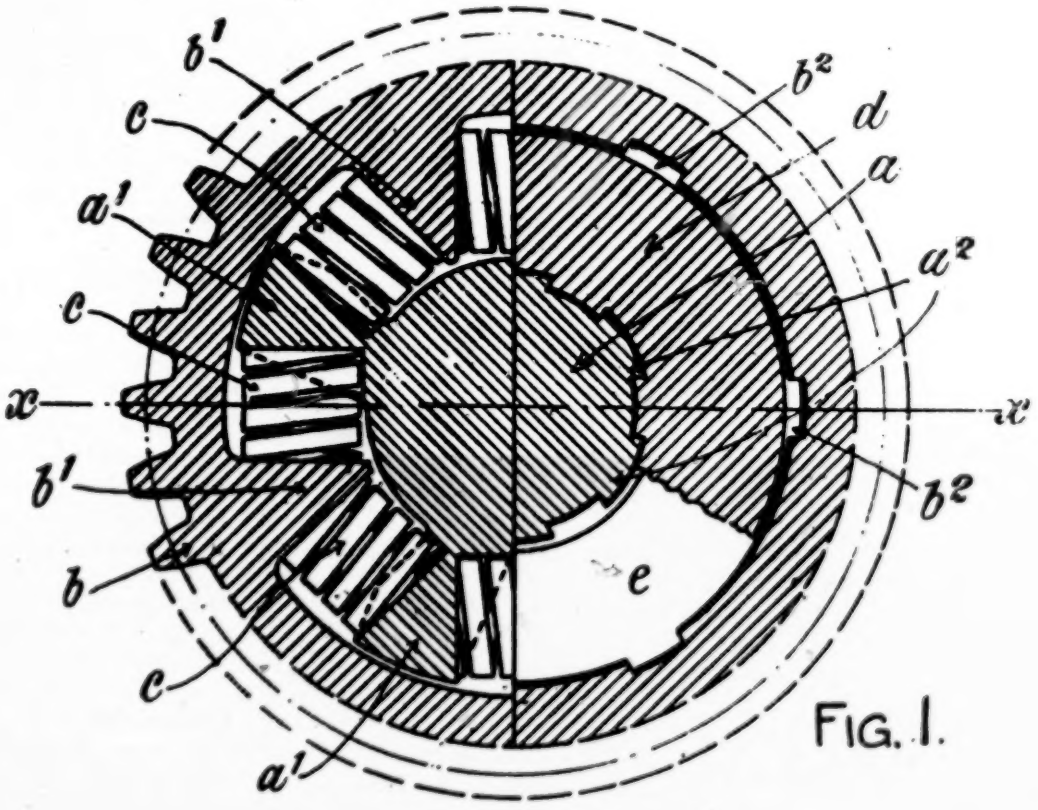

FIG. 1.

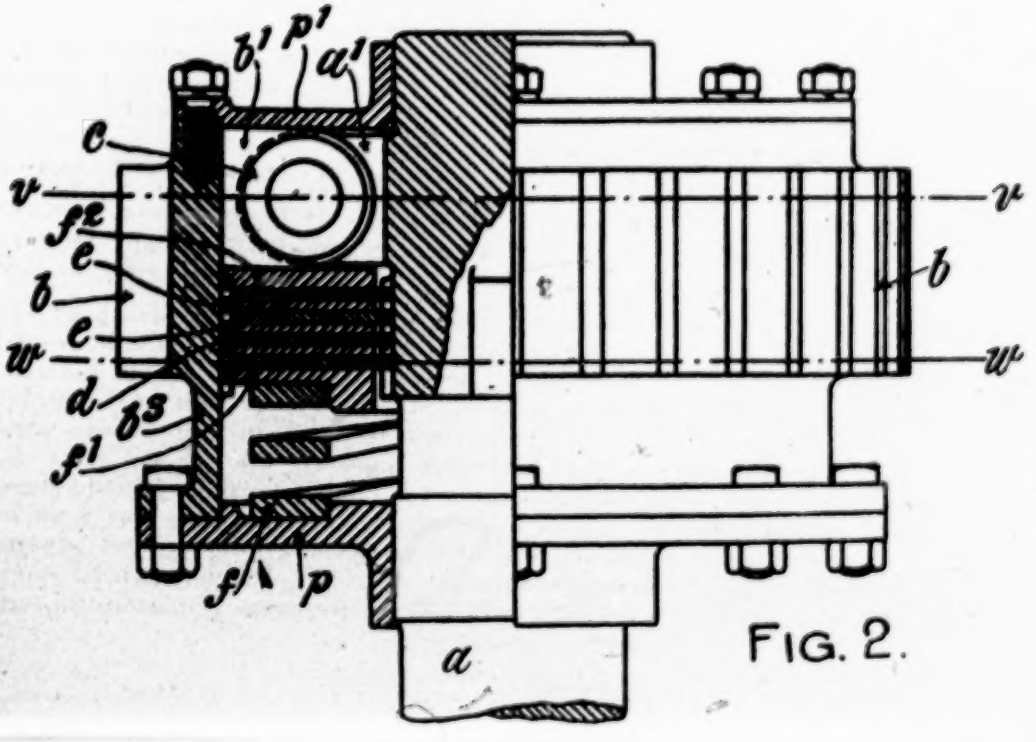

FIG. 2.

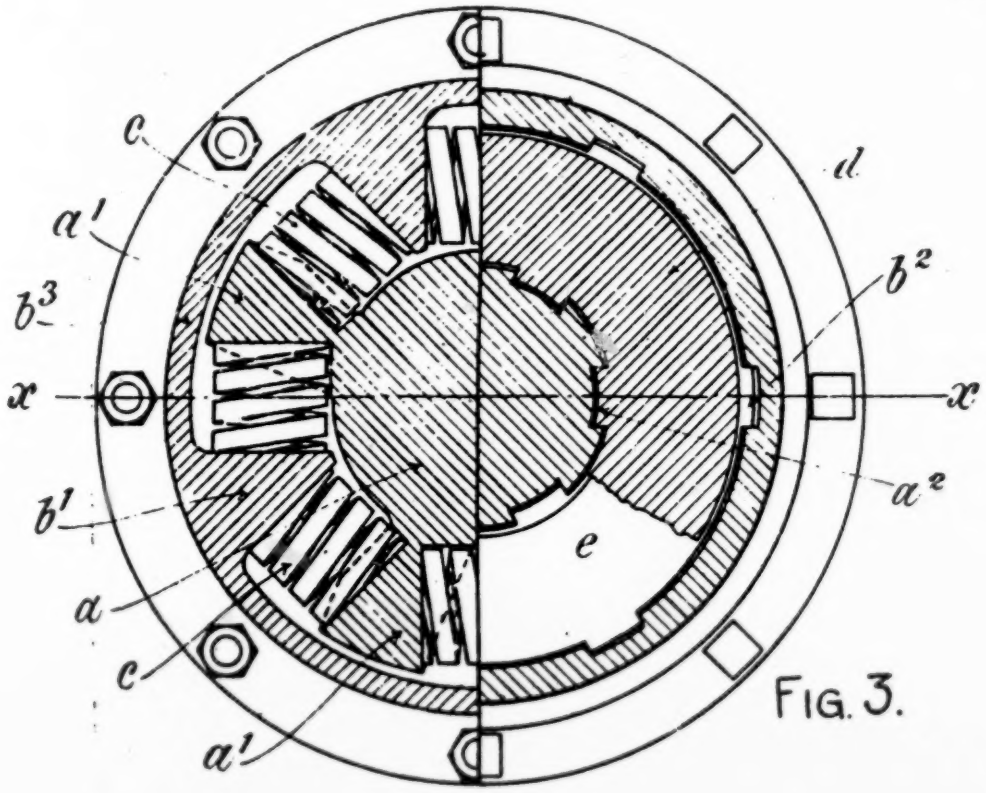

FIG. 3.

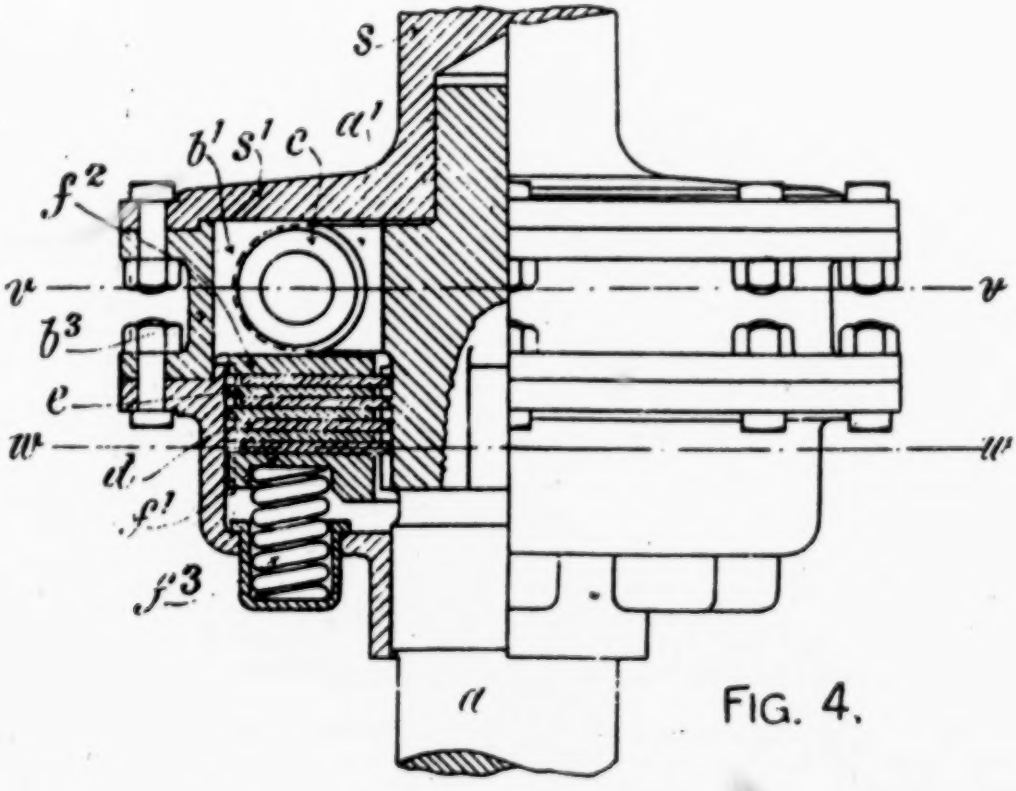

FIG. 4.

Malby & Sons, Photo-Litho.

PATENT OFFICE
179
CLASSIFICATION

115,942

PATENT SPECIFICATION

Application Date, June 25, 1917. No. 9080 17.
Complete Accepted, May 30, 1918.

COMPLETE SPECIFICATION.

Method of Recording and Reproducing Simultaneously Movements and Sounds.

I, HANS PEDERSEN, of 3, Istedgate, Copenhagen, Denmark, Patent Agent, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to a process for simultaneously recording—and for reproducing movements and sounds upon the film for taking the picture or scene. For this purpose the said film receives at the same time a photographic impression in the form of a wave-line which next is photographically transferred on to a metal band and then by an electrolytic process is caused to appear raised on the surface of the band so as to serve as matrix for impressing the sound-wave line on the rear of the finished positive film. At the reproduction of the cinematographic scene the fixed sound waves are by means of a stylus converted into corresponding oscillations of an electric current which through the medium of a membrane or through influence upon a flowing compressed air column or steam jet effects the reproduction of the sound.

The apparatus for recording the sounds comprises two separate parts. Part 1 is electrically connected to part 2 which is mounted on the cinematograph camera.

Part 1 consist merely of a funnel and telephone transmitter with encased electric battery, and is connected to part 2 by a main and return conductor.

Part 2 the whole width of the cinematograph film is not utilized for taking the pictures there being left on an inner margin along the perforation of a small width or strip which remains unexposed and which serves for the reception of the sound-waves. A telephone receiver is encased in a thoroughly soundproof and padded capsule so as not to be influenced by extraneous sounds or by the noise produced by the working of the cinematograph. The centre of the membrane is connected with a small and light plate which is held over the said unexposed strip of the film. This plate has a very fine round aperture through which a ray of light falls on the reserved margin of the film. The plate performs side-ways movements corresponding to the oscillations of the membrane and during the advancing motion of the film beneath the aperture it receives an exposure which takes the form of a fine wave-line similar to that on a gramophone plate. In developing the film the wave-line becomes black.

TRANSFERENCE OF THE SOUND WAVES ON TO THE POSITIVE FILM.

From the finished negative film the sound waves are first transferred on to a thin metal band. The latter is provided with a coat of lacquer all but a small strip which is coated with unexposed chromate-gelatine. This strip is then

exposed beneath the edge-strip or margin of the film, which is transparent all except the sound-wave line, the exposure rendering the chromate-gelatine all but the sound-wave insoluble. The latter is then washed out in warm water bath till the metallic sub-ground appears. Hereupon the metal band is placed in an electrolytic bath. As the band is protected up to the sound-wave line, the latter only receives a deposit of metal in the form of a raised ridge upon the metal band.

Thus prepared the metal band serves as matrix for impressing the sound-waves into the rear surface of the finished positive film by passing both together between rollers.

Procedure.

The reproduction is effected on similar principles as the production. Here also is the apparatus divided into two parts. Part 1 is within the picture projecting apparatus and part 2 is near the picture screen. Part 1 converts the oscillations of a stylus-needle, which glides in the wave-line of the film, into corresponding fluctuations of an electric current which excites an electromagnet in part 2. Owing to the difficulty of properly guiding the needle or stylus it is not advisable to use a membrane for a good and loud reproduction of the sound. This is to be effected through the action upon a flowing column of compressed air or steam jet by causing the electromagnet to move a small slide or damper in a manner to impart sound fluctuations to the flowing air column.

It is to be mentioned that the recording of the sound waves should be done at a position where the film receives uniform motion, for example on the delivery drum or feed reel. Similarly, the needle of the reproducing apparatus glides on the winding drum or uniformly rotating transmitting drum. The sound waves appertaining to a picture screen on the negative are not arranged immediately at the side of same but are disposed alongside of a subsequent picture. At the impressing operation the proper displacement has to be effected.

The sound is exceedingly sensitive to variation in rotating speed as will be noticed in any gramophone, and it is necessary to obviate this specially during the producing and the reproducing operations by providing particularly large flywheels for example.

If the celluloid of the positive film be found unsuitable for the impressing of the sound-wave line it may be necessary to make the impression on some other suitable substance.

The chromate-gelatine layer on the metal band must be so thin as to be quickly acted upon by light through the whole thickness to the base. It is advantageously coloured blue so that the chemical action of the light is not weakened, and the sound-wave line clearly appears after the washing operation. To ensure that the needle of the reproducing apparatus receives proper oscillations it is necessary that the film should be well pressed down at the particular place by rollers and to be protected against lateral displacement.

The accompanying drawing shows one form of construction of the apparatus, by way of example, for carrying out the method.

Fig. 1 shows the recording device for the taking of the cinematograph picture and the wave-line, while

Fig. 2 shows the reproducing device, the film being in both cases omitted.

a, *a* (Fig. 1) is a part of the apparatus, on the right of the drawing is the outside and on the left thereof, the inside of the apparatus. *b* is the ratchet-drum of the film, moved at constant velocity. The box *c* provided at the outside encloses at the upper part a small incandescent lamp *d* and at the lower part the electromagnet *e*, with the iron diaphragm *f*.

From the centre of the diaphragm, a pin *g* leads through the wall *a* and carries at its end the little plate *h*, having a fine opening as previously mentioned.

Cawley 1269

Through the intervention of *g*, the plate *h* participates in the oscillations of the diaphragm *f* and thereby causes the beam of light from the shaft *i* to trace a wavy line on the film. The shaft *i* tapers downwards and is light-tight with exception of the fine opening in *h*. The rays from *d* are concentrated by the lens *k* and the mirror *l* reflects them at right angles downwards.

Fig. 2 is the toothed drum moved at constant velocity and 2 is the pin sliding in the wave line for reproduction of the sound. The holder 3 of the pin is similar to that of a sound box. 4 is an electrically-insulating part. The current flows over the microphonic contacts 5 comprising two fine pointed wire brushes touching each other. By the oscillations of 3 they are telescoped more or less whereby the resistance of the microphone 5 is increased and reduced so that oscillations of the current, flowing through the brushes, are produced which correspond to the engraved line of the sound waves on the film.

Having now particularly described & ascertained the nature of my said invention & in what manner the same is to be performed, I declare that what I claim is:—

The combined process for simultaneously recording (and for reproducing) movements and sound, which is characterized in that the process, by which a film for receiving the cinematographic picture serves also in recording sound waves by receiving a luminous impression in the form of a wave-line which is next photographically transferred onto a metal band and then by an electrolytic process is caused to appear raised on the surface of said band so as to serve as matrix for impressing the sound-wave on the rea of the finished positive film, is conjoint with the process for the reproduction of sound through a stylus in a wave line, and transferring its oscillations to an electric current which through the intervention of a membrane or through the influence of air or steam pressure reproduces the sound.

Dated this 25th day of June, 1917.

CHATWIN, HERSCHELL & Co.,
253, Gray's Inn Road, London, W.C. 1,
Patent Agents for the Applicant.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1918.

[This Drawing is a full-size reproduction of the Original.]

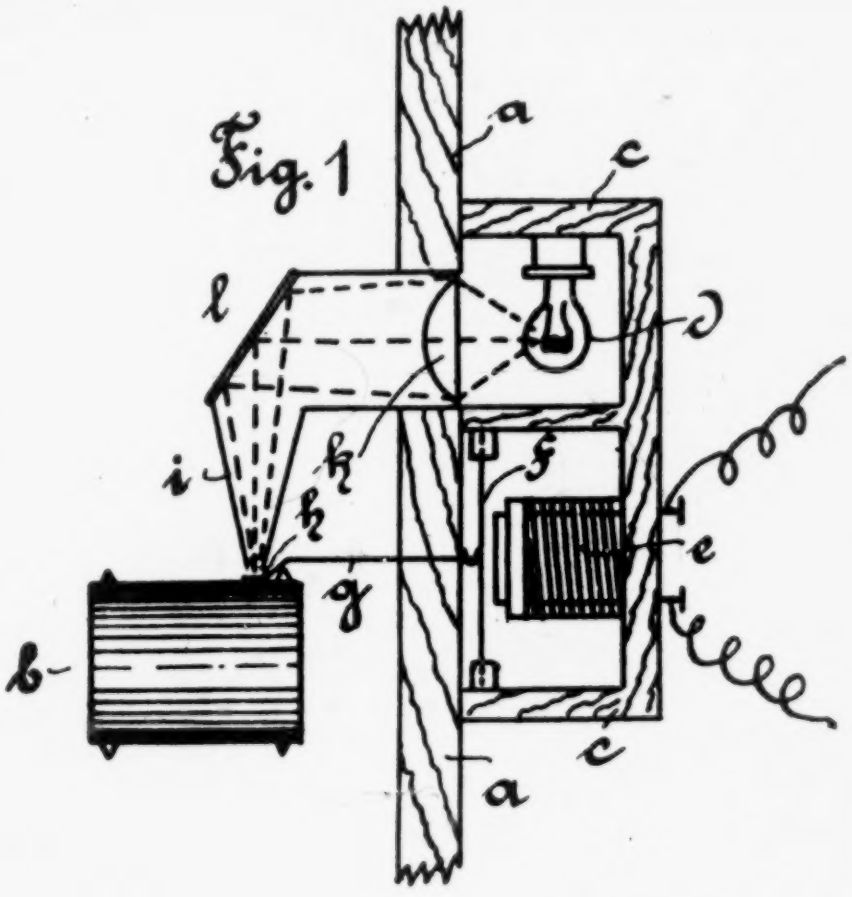

Fig. 1

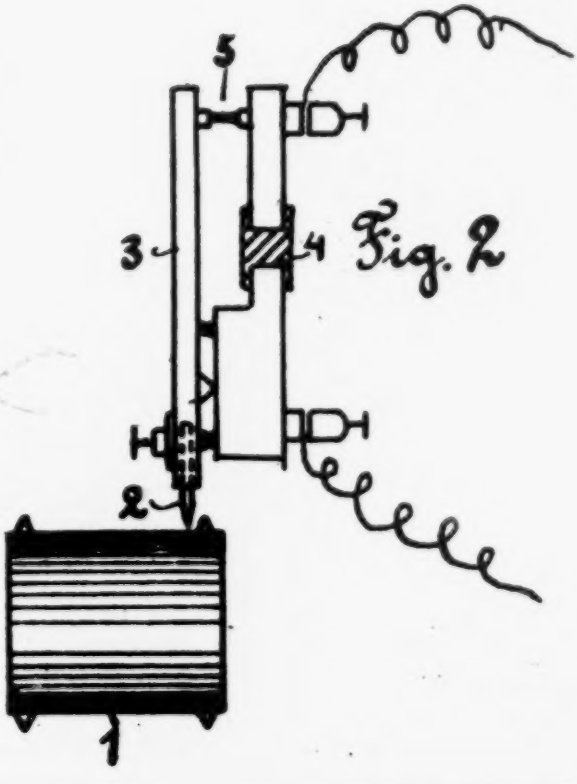

Fig. 2

Hanby & Sons, Photo-Litho.

1850 RÉPUBLIQUE FRANÇAISE.

OFFICE NATIONAL DE LA PROPRIÉTÉ INDUSTRIELLE.

BREVET D'INVENTION.

XII. — Instruments de précision, électricité.

2. — APPAREILS DE PHYSIQUE ET DE CHIMIE, OPTIQUE, ACOUSTIQUE.

N° 393.301

«Isosynchronisateur» ou appareil pour le fonctionnement synchronique d'un cinématographe avec un ou plusieurs gramophones.

Société dite : FABBRICA ITALIANA PELLICOLE PARLATE résidant en Italie.

Demandé le 14 mars 1908.

Délivré le 22 octobre 1908. — Publié le 19 décembre 1908.

(Demande de brevet déposée en Italie le 18 mai 1907. — Déclaration du déposant.)

Le présent appareil sert à produire le synchronisme entre le cinématographe et un ou plusieurs gramophones et autres machines parlantes ou similaires. Dans la fig. 1, la poulie A a deux gorges *a*, *b* et une manivelle *c*, et peut être mise en mouvement par la manivelle au moyen de la main ou au moyen d'un moteur quelconque par une corde placé sur la gorge *b*.

La gorge *a* porte une corde de cuir ou de spirale métallique ou de n'importe quelle autre matière, qui passe sur la poulie P, située sur l'axe XY.

La tension de la corde est réglée de manière à rendre possible un certain glissement de la corde sur la poulie P lisse.

L'axe X Y porte aussi un régulateur à force centrifuge R, muni du frein F, que l'on peut régler avec la vis M.

L'axe V V porte en outre un distributeur de courant D (qui est dessiné dans la fig. 3) et une roue dentée I, qui fait mouvoir l'autre roue dentée H fixe sur l'axe V Z, sur lequel est fixé également un pignon de bicyclette B. qui fait tourner au moyen d'une chaîne plus ou moins longue l'autre pignon B', qui a un moyen facilement applicable à l'axe de n'importe ment la roue A, le mouvement de la machine est isochrone grâce au régulateur, mais plus ou moins rapide selon la position du frein. Le régulateur R peut fonctionner en maintenant l'isochronisme, parce que la corde glisse sur la poulie P tandis que si le contact était rigide à engrenage ou à chaîne, on ne pourrait pas toujours régler la vitesse. Si au lieu de la main on emploie un moteur comme force motrice, l'axe du moteur peut porter une poulie avec une gorge, sur laquelle s'appuie la corde qui va à la gorge P.

Les machines cinématographiques en général ont une poulie métallique sur l'axe de l'obturateur, qui sert pour y appuyer une corde qui la joint à la poulie d'un moteur mécanique, quand on ne veut pas faire agir l'appareil avec la main. En se servant de cette disposition, pourvu que la corde glisse bien, on peut enlever la poulie A avec sa corde, et les choses restent inaltérées, et le frein agit également, parce qu'il est en rapport avec la propre poulie du cinématographe au moyen d'engrenages rigides.

En se servant de petits moteurs d'une certaine résistance ohmique ou moteurs électriques d'une force motrice un peu supérieure

La fig. 1 du dessin annexé à cette description montre en B l'aspect dudit ressort respectivement sans (à droite) et avec enveloppe-amortisseur (à gauche): la même figure montre aussi le mode particulier d'exécution du joint flexible et élastique.

Le joint doit en effet être facilement séparable, afin de pouvoir permettre dans le gramophone le changement rapide du disque chantant; ce but est atteint en faisant usage de deux chevilles disposées en fourchette et s'engageant dans deux trous percés dans le disque métallique d'entraînement.

Dans la même fig. 1, le bout de l'axe de l'organe mobile de l'appareil synchronisateur est marqué avec A et la fourchette d'entraînement avec C. Cette fourchette est dissymétrique et en correspondance avec les trous du disque métallique du gramophone dans lesquels s'engagent les branches de ladite fourchette et qui sont percés à distances différentes du centre du disque métallique. Ces détails sont clairement représentés dans la fig. 2 qui montre, vu par le dessous, le disque métallique du gramophone avec la dent d'arrêt D, tandis qu'avec F et G sont indiqués les trous d'entraînement. La fig. 3 montre le même disque métallique vu par le dessus; dans cette figure, on a représenté en E l'électro-aimant de déclenchement; D est l'extrémité de la dent d'arrêt, le groupe du parleur comprenant la boîte de la membrane et le porte-voix, F et G sont toujours les trous recevant les branches de la fourchette.

Le disque parleur doit être aussi pourvu de deux trous pratiqués à distances différentes de son centre et en correspondance exacte avec ceux du disque entraîneur; on évite ainsi toute incertitude dans le placement du disque parleur. Au lieu toutefois de faire usage à cet effet d'une fourchette à branches dissymétriques, on pourrait aussi employer une fourchette pourvue de chevilles d'une grosseur différente et s'engageant dans des trous de diamètres correspondants.

Le contrôle dans la position initiale du disque entraîneur (et par conséquent aussi du disque parleur) est réalisé au moyen de la dent d'arrêt, disposée dans la partie inférieure

phone est finie, le plateau métallique entraîné toujours par le ressort moteur tourne jusqu'à ce que la dent d'arrêt D (voir fig. 3) ne rencontre l'ancre de l'électro-aimant E frottant sur le bord du disque, ancre qu'on garde soulevée lorsque l'appareil est inactif au moyen d'un ressort qui n'est pas représenté dans le dessin. Pour éviter toute brusquerie dans l'arrêt, la dent D n'est pas appliquée d'une façon rigide au disque entraîneur, mais au contraire y est fixée au moyen d'un levier rappelé par un ressort S.

L'électro-aimant E, fixé sur le même socle qui enferme l'appareil moteur du gramophone et y occupant une position bien déterminée, est excité par le même courant (continu ou alternatif) qui actionne l'appareil.

Pour mettre pourtant le gramophone en état de fonctionner, il suffit de placer le disque parleur sur le plateau ou disque métallique entraîneur et l'y fixer au moyen de la fourchette. En envoyant au moyen d'un commutateur convenable un courant dans l'électro-aimant E, on dégagera l'arrêt et le disque commencera à tourner: on placera alors la pointe reproductrice pendant le premier tour. On comprend maintenant qu'avec un tel procédé et sans autre précaution que celle de pratiquer dans le disque parleur les trous dans une position invariable par rapport au commencement de l'incision sonore (cette opération pouvant d'ailleurs être effectuée facilement au moyen d'une machine convenable) le même disque parleur se trouve exactement dans la position exigée pour le départ. Cette condition est absolument nécessaire pour le fonctionnement simultané de plusieurs gramophones dont le départ peut alors être opéré au moyen d'un seul courant. En addition maintenant à ce qu'on a dit plus haut à propos de l'électro-aimant de déclenchement E, on doit remarquer que, lorsqu'on fait usage de courant alternatif, l'ancre dudit électro-aimant vibre, produisant de la sorte un bruit qui peut parfois être un ennui; pour éliminer cet inconvénient, il suffit de désinsérer l'enroulement de l'électro-aimant E immédiatement après l'attraction de l'ancre et de bloquer celle-ci en

OFFICE NATIONAL DE LA PROPRIÉTÉ INDUSTRIELLE.

BREVET D'INVENTION.

XII. — Instruments de précision, électricité.

2. — Appareils de physique et de chimie, optique, acoustique.

N° 393.301

«Isosynchronisateur» ou appareil pour le fonctionnement synchronique d'un cinématographe avec un ou plusieurs gramophones.

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L'axe X Y porte aussi un régulateur à force centrifuge R, muni du frein F, que l'on peut régler avec la vis M.

L'axe V V porte en outre un distributeur de courant D (qui est dessiné dans la fig. 3) et une roue dentée I, qui fait mouvoir l'autre roue dentée H fixe sur l'axe V Z, sur lequel est fixé également un pignon de bicyclette B. qui fait tourner au moyen d'une chaîne plus ou moins longue l'autre pignon B', qui a un moyen facilement applicable à l'axe de n'importe quelle machine cinématographique de prise ou de projection. En tournant n'importe comment la roue A, le mouvement de la machine est isochrone grâce au régulateur, mais plus ou moins rapide selon la position du frein. Le régulateur R peut fonctionner en maintenant l'isochronisme, parce que la corde glisse sur la poulie P tandis que si le contact était rigide à engrenage ou à chaîne, on ne pourrait pas toujours régler la vitesse. Si au lieu de la main on emploie un moteur comme force motrice, l'axe du moteur peut porter une poulie avec une gorge, sur laquelle s'appuie la corde qui va à la gorge P.

Les machines cinématographiques en général ont une poulie métallique sur l'axe de l'obturateur, qui sert pour y appuyer une corde qui la joint à la poulie d'un moteur mécanique, quand on ne veut pas faire agir l'appareil avec la main. En se servant de cette disposition, pourvu que la corde glisse bien, on peut enlever la poulie A avec sa corde, et les choses restent inaltérées, et le frein agit également, parce qu'il est en rapport avec la propre poulie du cinématographe au moyen d'engrenages rigides.

En se servant de petits moteurs d'une certaine résistance ohmique ou moteurs électriques d'une force motrice un peu supérieure à celle qui est nécessaire pour le mouvement (en série ou en dérivation) avec une résistance

tion montre en B l'aspect dudit ressort respectivement sans (à droite) et avec enveloppe-amortisseur (à gauche): la même figure montre aussi le mode particulier d'exécution du joint flexible et élastique.

Le joint doit en effet être facilement séparable, afin de pouvoir permettre dans le gramophone le changement rapide du disque chantant; ce but est atteint en faisant usage de deux chevilles disposées en fourchette et s'engageant dans deux trous percés dans le disque métallique d'entraînement.

Dans la même fig. 1, le bout de l'axe de l'organe mobile de l'appareil synchronisateur est marqué avec A et la fourchette d'entraînement avec C. Cette fourchette est dissymétrique et en correspondance avec les trous du disque métallique du gramophone dans lesquels s'engagent les branches de ladite fourchette et qui sont percés à distances différentes du centre du disque métallique. Ces détails sont clairement représentés dans la fig. 2 qui montre, vu par le dessous, le disque métallique du gramophone avec la dent d'arrêt D, tandis qu'avec F et G sont indiqués les trous d'entraînement. La fig. 3 montre le même disque métallique vu par le dessus; dans cette figure, on a représenté en E l'électro-aimant de déclenchement; D est l'extrémité de la dent d'arrêt, le groupe du parleur comprenant la boîte de la membrane et le porte-voix, F et G sont toujours les trous recevant les branches de la fourchette.

Le disque parleur doit être aussi pourvu de deux trous pratiqués à distances différentes de son centre et en correspondance exacte avec ceux du disque entraîneur; on évite ainsi toute incertitude dans le placement du disque parleur. Au lieu toutefois de faire usage à cet effet d'une fourchette à branches dissymétriques, on pourrait aussi employer une fourchette pourvue de chevilles d'une grosseur différente et s'engageant dans des trous de diamètres correspondants.

Le contrôle dans la position initiale du disque entraîneur (et par conséquent aussi du disque parleur) est réalisé au moyen de la dent d'arrêt, disposée dans la partie inférieure du disque d'entraînement et dans une position déterminée par rapport aux trous d'entraînement. Lorsque la pièce chantée par le gramophone est finie, le plateau métallique entraîné toujours par le ressort moteur tourne jusqu'à ce que la dent d'arrêt D (voir fig. 3) ne rencontre l'ancre de l'électro-aimant E frottant sur le bord du disque, ancre qu'on garde soulevée lorsque l'appareil est inactif au moyen d'un ressort qui n'est pas représenté dans le dessin. Pour éviter toute brusquerie dans l'arrêt, la dent D n'est pas appliquée d'une façon rigide au disque entraîneur, mais au contraire y est fixée au moyen d'un levier rappelé par un ressort S.

L'électro-aimant E, fixé sur le même socle qui enferme l'appareil moteur du gramophone et y occupant une position bien déterminée, est excité par le même courant (continu ou alternatif) qui actionne l'appareil.

Pour mettre pourtant le gramophone en état de fonctionner, il suffit de placer le disque parleur sur le plateau ou disque métallique entraîneur et l'y fixer au moyen de la fourchette. En envoyant au moyen d'un commutateur convenable un courant dans l'électro-aimant E, on dégagera l'arrêt et le disque commencera à tourner: on placera alors la pointe reproductrice pendant le premier tour. On comprend maintenant qu'avec un tel procédé et sans autre précaution que celle de pratiquer dans le disque parleur les trous dans une position invariable par rapport au commencement de l'incision sonore (cette opération pouvant d'ailleurs être effectuée facilement au moyen d'une machine convenable) le même disque parleur se trouve exactement dans la position exigée pour le départ. Cette condition est absolument nécessaire pour le fonctionnement simultané de plusieurs gramophones dont le départ peut alors être opéré au moyen d'un seul courant. En addition maintenant à ce qu'on a dit plus haut à propos de l'électro-aimant de déclenchement E, on doit remarquer que, lorsqu'on fait usage de courant alternatif, l'ancre dudit électro-aimant vibre, produisant de la sorte un bruit qui peut parfois être un ennui; pour éliminer cet inconvénient, il suffit de désinsérer l'enroulement de l'électro-aimant E immédiatement après l'attraction de l'ancre et de bloquer celle-ci en empêchant qu'elle puisse retomber et frotter sur le bord du disque entraîneur.

Dans le commencement de cet exposé, on a parlé d'un dispositif mécanique permettant la

mise hors de fonctionnement de l'arbre du distributeur (voir description annexée au brevet principal) lorsque le cinématographe doit marcher seul. Avec la disposition de commande du cinématographe décrite dans le mémoire annexé au brevet principal, l'opérateur est obligé de faire fonctionner toujours le distributeur (et par conséquent aussi le synchronisateur agrégé au gramophone), à moins d'enlever la chaîne qui lui transmet le mouvement, même lorsque la scène n'est pas chantée. Pour éliminer cet inconvénient, on a remplacé le simple pignon de bicyclette disposé sur l'appareil cinématographique avec un pignon semblable à ceux à roue libre et dont les deux parties (celle mobile et celle fixe) peuvent être rendues solidaires au moyen d'un accouplement lorsque la mise en marche doit être faite à la main. A la partie centrale de ce dispositif est adaptée la manivelle au moyen de laquelle on fait marcher le cinématographe tandis que les autres organes demeurent immobiles.

RÉSUMÉ.

Un joint flexible, élastique et facilement soluble, réunissant l'axe de l'appareil synchronisateur avec l'axe du gramophone et essentiellement composé par un ressort à boudin relié d'un côté à l'axe du synchronisateur et de l'autre côté se terminant par une fourchette dissymétrique dont les branches s'engagent dans deux trous percés dans le plateau métallique qui entraîne le disque parleur, ledit joint ayant pour effet de régulariser le mouvement du gramophone en supprimant les petits chocs dus à l'action de l'appareil synchronisateur;

Un dispositif mécanique permettant de dégager le cinématographe de l'ensemble des organes qui contrôlent la synchronisation constitué par un pignon à roue libre remplaçant le pignon de commande ordinaire.

Société dite : FABBRICA ITALIANA PELLICOLE PARLATE.

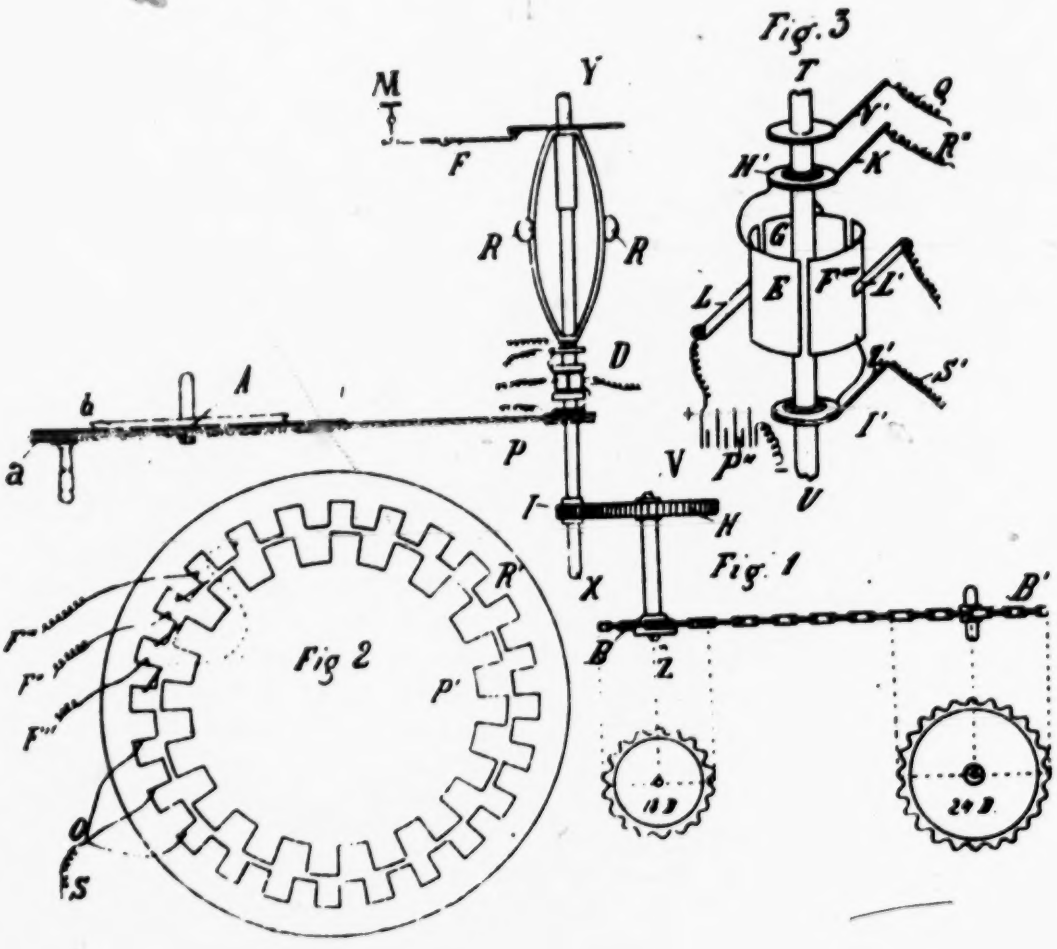
Par procuration :

J. Bonnet-Thirion.

N° 393.301

Société dite :
Fabbrica Italiana Pellicole Parlate

Pl. unique



Translation.

FRENCH PATENT No. 393301.

Filed March 14, 1908.

"Isosynchronizer" or apparatus for the synchronous operation of a motion picture apparatus with one or several gramophones.

(Claimant: Fabbrica Italiana Pellicole Parlate, Italy.)

The present apparatus is used for producing synchronism between the motion picture apparatus and one or several gramophones and other talking machines or the like. In Fig. 1 the pulley *A* has two grooves *a, b* and a crank *c* and can be set in motion by the crank with the aid of the hand or by any motor by way of a cord placed in the groove *b*.

The groove *a* carries a cord of leather or metal spiral or any other material which runs over the pulley *P* placed on the axle *XY*.

The tension of the cord is adjusted so as to make possible a certain slip of the cord on the smooth pulley *P*.

The axle *XY* also carries a centrifugal governor *R*, equipped with the brake *F* which can be adjusted by the screw *M*.

The axle *XY* also carries a current distributor *D* (which is illustrated in Fig. 3) and a toothed wheel *I* which actuates the other toothed wheel *H* fixed on the axle *VZ* on which also a bicycle pinion *B* is fixed, which by means of a chain which is more or less long rotates the other pinion *B'* which has a nave which readily can be applied to the axle of any motion picture recording or projecting apparatus. By rotating the wheel *A* in any manner the movement of the machine is isochro-

nous owing to the governor, but more or less rapid according to the position of the brake. The governor *R* can operate and maintain the isochronism because the cord slides on the pulley *P* whereas, if the contact were rigidly geared or chained, the speed could not always be regulated. If a motor is used instead of the hand as driving force, the axle of the motor can have a pulley with a groove which supports the cord which runs to the groove *P*.

Motion picture machine in general have a metallic pulley on the axle of the shutter, which supports a cord which joins it to the pulley of a mechanical motor when the apparatus is not operated by hand. When this arrangement is used and provided that the cord slides easily, the pulley *A* with its cord can be removed and things remain unchanged and the brake also operates because it is connected with the pulley of the motion picture apparatus by means of rigid gears.

When small motors of a given ohmic resistance are used or electric motors of a motive power which is slightly higher than the power necessary for the movement (in series or shunted) with a resistance in series with the armature, the brake acts upon the speed of the motor and isochronism is established even if the contact of the pulleys *A* and *P* is rigid.

The slip which is indispensible in order that the governor can maintain isochronism can be obtained with other means already in use independently of the system described above; but the described system is a very simple system and serves the purpose perfectly. Needless to say the angular velocity transmitted to the axle *XY* should be such that the brake begins to function.

Fig. 2 shows an iron wheel *R'* which on the inside has a certain number of teeth; some are marked with progressive numerals 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, etc.

An insulated copper wire F', only the beginning of which is indicated in the figure, is wound on the teeth 1, 4, 7, 10, etc. always in the same direction.

A current polarizes all of them in the same direction.

Another wire F'' as indicated in the figure is wound on the teeth 2, 5, 8, etc. always in the same direction and in the same direction as the first wire.

A third wire F''' is wound on the teeth 3, 6, 9, etc. The ends of the three wires are joined together at O and this single end can be joined to a wire S for the following purpose:

Concentrically to the wheel R', which is toothed on the inside and moves on a spherical axle not indicated in the figure, another iron wheel P' is placed which also is toothed but on the outside and the number of teeth is expressed by 2.n in regard to wheel R'. On these teeth or poles a wire is wound alternately in both directions in such a manner that a current polarizes them alternately in the opposite sense. A small air gap which permits the rotation of the wheel P' is located between the poles of the two wheels.

During operation the teeth of the wheel P' are magnetized by the current. In the figure the magnetizing wire is not indicated or the manner of conveying the current to this wire.

Since the wheel should be movable, however, it is clear that the current will be supplied by means of two brushes with two rings as usual in similar cases.

The current which polarizes the internal wheel P' can be the same current which polarizes the external wheel. In this case the wheel P' is in series and it always should be placed in this manner when an alternating current is used in order to prevent a phase displacement between the two currents which flow to R' and to P'.

When a direct current is concerned, it can be obtained from the source of electricity or it can be a direct current generated separately; or the winding of the wheel can be closed by short-circuit or the winding can be eliminated and polarized teeth of steel be employed.

The distributor *D* in Fig. 1 is illustrated in Fig. 3. It consists of a metallic sleeve divided into three equal parts, *E*, *F''''*, *G*, insulated from one another and from the axle *TV* on which they are adjusted; only *G* is metallicly connected; *E* communicates with the metallic ring *H'*; *F''''* with the metallic ring *I'*. The three brushes *K*, *V'*, *Z'* establish connections between the rings *H'* and *I'* and the axle *TU* and the wires *Q*, *R*, *S*.

Two brushes *I*, *I'* are tangents to the above distributor at diametrical points. A generator *P'* supplies the current. A pole of the generator is connected to the brush *L* of Fig. 3; the other pole is connected to point *O* which joins the ultimate ends of the wires, *F'*, *F''*, *F''''* of Fig. 2.

The three wires *Q*, *R*, *S'* of Fig. 3 are connected to the beginning of the wires *F'*, *F''*, *F''''*.

In rotating the distributor the current acts alternately upon the electromagnets 1, 4, 7, 10, etc.; 2, 5, 8, etc.; 3, 6, 9, etc. of the wheel *R'* and the polarized internal armature will rotate; the number of revolutions of the latter will bear the ratio of 1/n to the number of revolutions of the distributor.

In this case the number of magnets of the external wheel *R'* which are polarized by the current is ⅓ of the whole. If the second pole of the generator instead of communicating with *O* of Fig. 2 communicates with brush *L'* of Fig. 3, the current will be distributed also to another third of electromagnets by means of this brush and this is the best system.

The end of wire *F'* also can be joined to the beginning of wire *F''* and the end of the latter to the begin-

ning of wire *F''''* and the three points of connection made communicating.

In rotating the distributor the internal wheel of Fig. 2 also rotates and the system can be moving. It is used as governor or brake, however.

The axle of the internal wheel is in one piece with the axle of the gramophone whose spring is charged while the governor of the gramophone is started at its highest speed. If current does not flow, the gramophone rotates fast; if current flows, the gramophone rotates as fast as it is permitted by the system of the wheels *R'* and *P'* which constitute an electric brake which rotates in connection with the distributor.

Since the system in Fig. 2 is passive, the electric energy consumed is very small and absolute synchronism of the systems can be obtained even with a few single cells, that is to say, in the place where no direct or alternating currents are flowing. A reference mark should be made on the film and another mark at the corresponding point on the gramophone record.

A small electro-magnet in the path of the current which flows to the wheel *P'* attracts an anchor which detaches the brake of the gramophone.

It was stated above that the external wheel of Fig. 2 has a number of teeth or poles equal to 3.n; it should be added that a similar operation is obtained with a wheel having 2.n teeth because the system is not moving but passive, and consequently the dead centre which it would have if the system were active need not be considered.

The number should be as 6 to 8 in order to obtain a good adjustment of the operation. A smaller number makes its action felt on the sound; a larger number increases the inertia of the system.

With regard to the operation it is clear that the distributor has a more or less rapid but isochronous movement. The movable system of Fig. 2 and con-

sequently the gramophone which is in one piece with it and synchronous with an isochronous system also is isochronous; this is a condition of operation of talking machines.

The same distributor may operate several and even a large number of gramophones simultaneously to great advantage, whether they are in simultaneous action or in accord.

Resumé

The electrical apparatus is used for the synchronous operation of a motion picture apparatus and one or several gramophones.

This apparatus consists essentially of a rotating drum with different sections which distributes the current to a system which regulates the movement of the gramophone.

The arrangement of the speed adjustment of the distributor consisting of a spring governor equipped with a brake; the adjustment is made possible by the slip of a cord resting on a pulley placed on the axle of the governor.

The movement of the distributor produced by hand or by a motor equipped with a belt sliding on the pulley keyed on the axle of the distributor.

The motor can be applied directly on the pulley of the motion picture apparatus. The distributor can be divided in two or three sections.

The system of two wheels which can be moving or act as a brake; the internal wheel having a number of teeth equal to or in a given ratio to those of the external wheel; the manner of polarization.

The apparatus can operate both with direct current and with alternating current.

The same distributor can operate several gramophones simultaneously.

The apparatus serves both as recording apparatus and as projecting apparatus.

Defendants' Exhibits Nos. 74 and 75 Consolidated
(Continued).

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RÉPUBLIQUE FRANÇAISE.

OFFICE NATIONAL DE LA PROPRIÉTÉ INDUSTRIELLE.

W51-22

1re ADDITION
AU BREVET D'INVENTION
N° 393.301

XII. — Instruments de précision, électricité.
2. — Appareils de physique et de chimie, optique, acoustique.

N° 10.377

« Isosynchronisateur » ou appareil pour le fonctionnement synchronique d'un cinématographe avec un ou plusieurs gramophones.

Société dite : FABBRICA ITALIANA PELLICOLE PARLATE résidant en Italie.

(Brevet principal pris le 14 mars 1908.)

Demandée le 21 janvier 1909.
Délivrée le 7 avril 1909. — Publiée le 24 juin 1909.

Les perfectionnements dans l'appareil breveté sont représentés schématiquement, tant pour la partie électrique que pour la partie mécanique, aux fig. 1-2-3 jointes au présent mémoire descriptif.

Un premier perfectionnement concerne un joint élastique réunissant un bout de l'arbre de l'armature P' (voir dessin annexé à la description principale) avec le disque entraîné fixé à l'axe du gramophone. Ce serait peu pratique de faire usage à cet effet d'un accouplement rigide (par exemple à manchon), soit parce que cette solution nécessiterait un alignement parfait dans les axes, sans quoi on pourrait donner origine à des frottements considérables, soit parce que les dents dont est pourvue l'armature mobile P' donnant toujours lieu à des petits chocs dans la marche du synchronisateur, on aurait de ce chef une marche irrégulière dans le gramophone.

Un double joint à la cardan réunissant les deux axes susdits, tout en permettant une rigoureuse transmission du mouvement, ne pourrait pas éliminer ce dernier inconvénient et le mouvement du gramophone, subissant toujours l'action des petits chocs imprimés par l'organe mobile du synchronisateur, rendrait tremblotant le son émis par l'appareil. La disposition décrite, bien qu'étant d'une exécution très facile, permet d'éloigner tout inconvénient. Un ressort à boudin en fil métallique a ses extrémités fixées à celles de l'arbre du synchronisateur et du gramophone respectivement; une disposition de ce genre fonctionne comme transmission flexible et élastique, évitant les frottements se produisant lorsque les axes ne sont pas alignés, et absorbe, au moyen de variations dans la torsion du ressort, les irrégularités qui ont lieu dans la régulation du mouvement. On a reconnu toutefois, en pratique, nécessaire d'éviter l'établissement d'un mouvement oscillatoire, qui pourrait se produire à cause de la présence du ressort lorsque les variations dans son état de torsion sont trop brusques, ledit mouvement oscillatoire pouvant donner lieu à des irrégularités sensibles dans le mouvement du gramophone.

On doit pourtant chercher à amortir au moyen du frottement les oscillations du ressort sans cependant lui ôter la flexibilité et l'élasticité primitives. A cet effet, le ressort à boudin est étroitement bandé avec un ruban, lié ensuite avec de la ficelle et enfin recouvert avec un manchon en gomme élastique.

Prix du fascicule : 1 franc.

en série avec l'induit, le frein agit sur la vitesse du moteur et l'on a ainsi l'isochronisme, même si le contact des poulies A et P est rigide.

Le glissement qui est indispensable pour que le régulateur puisse maintenir l'isochronisme, peut s'obtenir, indépendamment du système décrit plus haut, avec d'autres moyens déjà pratiqués; mais le système indiqué est un des plus simples et il répond parfaitement à son but. Il est inutile de dire, que la vitesse angulaire transmise à l'axe X Y doit être telle que le frein entre en fonction.

La fig. 2 représente une roue R' en fer, qui a à l'intérieur un certain nombre de dents; quelques-unes sont marquées avec les numéros progressifs 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, etc.

Un fil de cuivre isolé F', dont le commencement seulement est indiqué dans la figure, est enroulé toujours dans le même sens sur les dents 1, 4, 7, 10, etc.

Un courant les polarise toutes en un sens.

Un second fil F'', comme l'indique la figure, est enroulé toujours dans le même sens, et dans le même sens que le premier sur les dents 2, 5, 8, etc.

Un troisième fil F''' est enroulé sur les dents 3, 6, 9, etc. Les bouts des trois fils sont réunis ensemble en O, et cette extrémité unique peut se joindre à un fil S dans le but suivant :

Concentriquement à la roue dentée R', intérieurement, et mobile sur un axe, à sphères, non indiqué dans la figure, se trouve une autre roue P' en fer, également dentée, mais à l'extérieur, et le nombre des dents est exprimé par rapport à la roue R' par 2. 3. Sur ces dents ou pôles est enroulé un fil alternativement dans un sens et dans l'autre, de façon à ce qu'un courant les polarise alternativement en nom contraire. Entre les pôles des deux roues, se trouve un petit entrefer, qui rend possible la rotation de la roue P.

Pendant le fonctionnement les dents de la roue P' sont magnétisées par le courant. Dans la figure on n'a pas indiqué le fil magnétisant, ni la manière de porter le courant à ce fil.

Mais comme la roue doit être mobile, on comprend que le courant sera porté au moyen de deux brosses à deux anneaux, comme l'on fait toujours dans les cas semblables.

Le courant qui polarise la roue intérieure P' peut être le même qui polarise la roue extérieure. En ce cas la roue P' est en série, et on doit toujours la placer de cette façon quand on emploie un courant alterné pour empêcher un déphasement entre les deux courants qui vont à R' et à P'.

Quand il s'agit d'un courant continu, il peut être dérivé de la source d'électricité ou être un courant continu engendré séparément; ou bien l'enroulement de la roue peut se fermer en court-circuit ou même l'on peut supprimer l'enroulement ou employer des dents d'acier polarisées.

Le distributeur D de la fig. 1 est représenté dans la fig. 3. Il consiste en un manchon métallique divisé en trois parties égales E, F'''', G, isolées entre elles et de l'axe T V sur lequel elles sont ajustées; seulement G y est en rapport métallique; E communique avec l'anneau métallique H'; F'''' avec l'anneau métallique I'. Les trois brosses K, V', Z' établissent les communications des anneaux H' et I' et de l'axe T U avec les fils Q, R, S'.

Deux brosses I, I' sont tangentes au distributeur susdit en des points diamétraux. Un générateur P'' fournit le courant. Un pôle du générateur communique avec la brosse I de la fig. 3; l'autre pôle communique avec le point O de réunion des extrémités finales des fils de la fig. 2, F', F'', F'''.

Les trois fils Q, R, S' de la fig. 3 communiquent avec les fils F', F'', F''' à leur commencement.

En faisant tourner le distributeur, le courant agit alternativement sur les électro-aimants 1, 4, 7, 10, etc.; 2, 5, 8, etc. 3, 6, 9, etc., de la roue R', et l'armature intérieure polarisée tournera; le nombre de tours qu'elle fera sera à celui du distributeur comme 1/3.

En ce cas, le nombre des aimants de la roue extérieure R' polarisés par le courant est 1/3 de toutes. Si le second pôle du générateur, au lieu de communiquer avec O de la fig. 2, communique avec la brosse I.' de la fig. 3, alors au moyen de cette brosse le courant est distribué aussi à un autre tiers des électro-aimants, et c'est le meilleur système.

L'extrémité du fil F'' peut aussi se réunir au commencement du fil F''' et le bout de celui-ci au commencement du fil F'''' et faire communiquer les trois points de conjonction.

En faisant tourner le distributeur, la roue intérieure de la fig. 2 tourne aussi et le système peut être moteur. Mais on s'en sert comme régulateur ou frein.

En effet, l'axe de la roue intérieure est solidaire avec l'axe du gramophone, dont le ressort est chargé tandis que le régulateur du gramophone est mis à sa plus grande vitesse. Si le courant ne passe pas, le gramophone tourne vite : si le courant passe, le gramophone tourne autant que le lui permet le système des roues R' et P', lesquelles constituent un frein électrique qui tourne en rapport avec le distributeur.

Comme le système de la fig. 2 est passif, l'énergie électrique dépensée est minime et l'on peut obtenir le synchronisme absolu des systèmes même avec quelques simples piles, c'est-à-dire là-même où il n'y a pas des courants continus ou alternatifs sur la voie. Il faut faire un signe de rapport sur la pellicule et un autre signe au point correspondant sur le disque du gramophone.

Un petit électro-aimant, au passage du courant qui va à la roue P', attire une ancre qui détache le frein du gramophone.

On a dit plus haut que la roue extérieure de la fig. 2 a un nombre de dents ou pôles égal à $3.n$: on doit ajouter que l'on a un fonctionnement pareil avec une roue de $2.n$ dents, parce que le système n'est pas moteur, mais passif, et il ne faut par conséquent pas considérer le point mort qu'il y aurait si le système était actif.

Le nombre, pour que le fonctionnement soit bien réglé, doit être comme 6 est à 8. Un nombre moindre fait ressentir son action sur le son : un nombre plus grand augmente l'inertie du système.

Quant au fonctionnement on comprend que le distributeur a un mouvement plus ou moins rapide mais isochrone. Le système mobile de la fig. 2, et conséquemment le gramophone qui lui est solidaire, synchronique à un système isochrone, est lui aussi isochrone : et c'est là une condition du fonctionnement des machines parlantes.

Un même distributeur peut faire fonctionner plusieurs et un grand nombre même de gramophones simultanément, qu'ils soient à l'unisson ou en accord avec grand avantage.

RÉSUMÉ.

L'appareil électrique sert pour le fonctionnement synchronique d'un cinématographe et d'un ou plusieurs gramophones.

Cet appareil est constitué essentiellement par un tambour tournant à différentes sections qui distribue le courant à un système régulateur du mouvement du gramophone.

La disposition du réglage de la vitesse du distributeur constitué par un régulateur à ressort muni d'un frein propre ; le réglage est possible grâce au glissement d'une corde s'appuyant sur une poulie placée à l'axe du régulateur.

Le mouvement du distributeur produit au moyen de la main ou d'un moteur muni d'une courroie glissant sur la poulie clavetée sur l'axe du distributeur.

Le moteur peut s'appliquer directement sur la poulie du cinématographe. Le distributeur peut être à deux ou à trois sections.

Le système des deux roues, système qui peut être moteur ou agir comme frein : la roue intérieure ayant un nombre de dents égal ou dans un rapport donné avec celles de la roue extérieure ; la manière de polarisation.

L'appareil peut fonctionner aussi bien avec le courant continu qu'avec le courant alternatif.

Un même distributeur peut faire agir plusieurs gramophones simultanément.

L'appareil sert aussi bien pour machine de prise que pour la machine de projection.

Société dite :

FABBRICA ITALIANA PELLICOLE PARLATE.

Par procuration :

Ch. Tellier et J. Bonnet.

N° 10.377 Societe dite : Pl. unique
Fabbrica Italiana Pellicole Parlate

Fig. 1

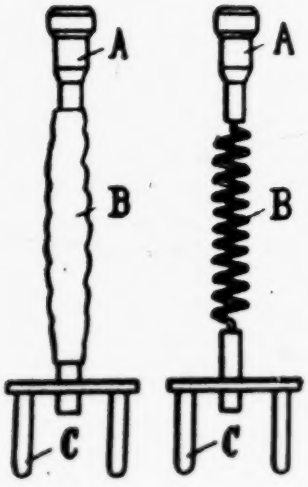


Fig. 2

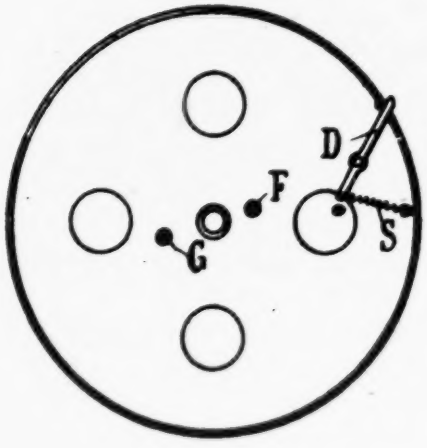
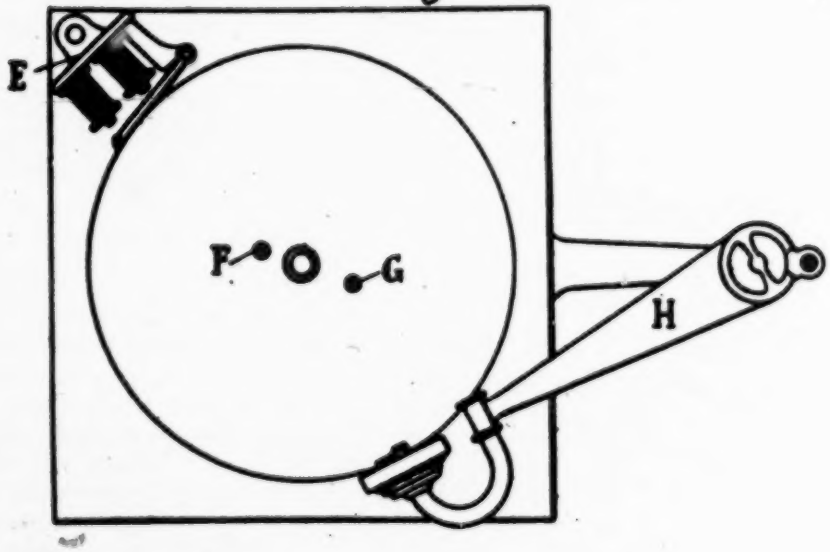


Fig. 3.



Translation.

FRENCH PATENT No. 10,377
FIRST ADDITION TO PATENT No. 393,301
Patented January 21, 1909.

Inventor: Fabrica Italiana Pellicole Parlate

"Isosynchronizer" or Apparatus for a synchronous Operation of a Motion Picture Apparatus with One or More Gramophones.

The improvements in the patented apparatus are illustrated schematically in Figs. 1, 2, 3, accompanying the present specification, both for the electrical part and the mechanical part.

One improvement refers to an elastic joint connecting an end of the shaft of the armature *P'* (see drawing accompanying the principal specification) to the moved disc fixed on the axle of the gramophone. It would be impractical to use a tight coupling for this purpose (muff coupling, for instance), either because this solution would necessitate a perfect alignment in the axles, without which considerable friction could result, or because, since the teeth with which the movable armature *P'* is provided always give rise to slight shocks in the operation of the synchronizer, an irregular operation in the gramophone would result from this source.

Although a double universal joint connecting said two axles would permit a rigorous transmission of the movement, it could not eliminate the latter disadvantage, and the movement of the gramophone which always is subject to the action of slight shocks communicated by the moving device of the synchronizer would make the sound emitted by the apparatus tremulous. Although being very easy to construct the de-

scribed arrangement permits of eliminating any disadvantage. The ends of a helical spring of metal wire are attached to the ends of the shaft of the synchronizer and of the gramophone, respectively; an arrangement of this kind operates as a flexible and elastic drive, avoiding the friction which results when the axles are not in line and absorbs the irregularities involved in the regulation of the motion by means of variations in the torsion of the spring. In practice, however, it has been found necessary to avoid an oscillatory motion which could be produced by the presence of the spring when the variations in its state of torsion are too sudden, said oscillatory motion giving rise to noticeable irregularities in the movement of the gramophone.

Attempts should be made to damp the oscillations of the spring by means of friction without depriving it of its original flexibility and elasticity. For this purpose the helical spring is tightly wound with a tape, then fastened with string and finally covered with a casing of gum elastic.

In Fig. 1 of the drawing accompanying this specification *B* designates said spring without casing (on the right) and with casing (on the left), respectively; the same figure also shows the special mode of construction of the flexible and elastic joint.

The joint should be readily separable in order to permit a rapid change of the disc record in the gramophone; this is obtained by means of two pins placed in the form of a fork and engaging in two holes made in the metallic turntable.

In the same Fig. 1 the end of the axle of the movable part of the synchronizing apparatus is indicated by *A* and the driving fork by *C*. This fork is unsymmetrical and corresponds to the holes of the metallic disc of the gramophone, in which the arms of said fork engage and which are made at different distances

from the center of the metallic disc. These details are clearly illustrated in Fig. 2 which shows a bottom view of the metallic disc of the gramophone with the ratchet tooth *D* whereas the driving holes are indicated by *F* and *G*. Fig. 3 shows the same metallic disc seen from above; in this figure *E* represents the release magnet; *D* is the end of the ratchet tooth, the speaking unit comprising the case of the diaphragm and the speaking trumpet, *F* and *G* are the holes receiving the arms of the fork.

The sound record also should be provided with holes made at different distances from its center and corresponding exactly to those of the turntable; thus any uncertainty in placing the sound record is avoided. Instead of using a fork with unsymmetrical arms for this purpose, however, a fork provided with pins of different size can be used which engage in holes of corresponding diameters.

The control in the initial position of the turntable (and consequently also of the sound record) is performed by means of the ratchet tooth placed in the lower part of the turntable and in a given position in regard to the driving holes. When the selection played by the gramophone is ended, the metallic plate, always driven by the moving spring, rotates until the ratchet tooth *D* (see Fig. 3) meets the anchor of the electromagnet *E* rubbing on the edge of the disc, this anchor being kept raised when the apparatus is at rest by means of a spring which is not illustrated in the drawing. In order to avoid an abrupt stop the tooth *D* is not applied in a rigid manner to the turntable but on the contrary is fixed by means of a lever restored by a spring *S*.

The electromagnet *E* which is fixed on the same stand which encloses the driving apparatus of the grampophone and has a definite position there is excited by the same current (direct or alternating current) which actuates the apparatus.

Thus in order to set the gramophone in motion, it is sufficient to place the sound record on the metallic turntable or plate and attach it by means of the fork. By sending a current into the electromagnet *E* by means of a suitable commutator the stop is released and the record begins to rotate; the reproducing needle is placed on it during the first revolution. It now is clear that with such a procedure and without other precaution than making the holes in the sound record in an invariable position in regard to the beginning of the sound cutting (this operation, moreover, can be readily performed by means of a suitable machine), the sound record is exactly in the position required for starting. This condition is absolutely necessary for the simultaneous operation of several gramophones which then can be started by means of a single current. In addition to that which has been said above in regard to the release magnet *E* attention is called to the fact that when alternating current is used, the anchor of said electromagnet vibrates, thus producing a noise which occasionally can be annoying; in order to eliminate this disadvantage it is sufficient to disconnect the winding of the electromagnet *E* immediately after the anchor is attracted and to block the latter, preventing it from falling down and rubbing on the edge of the turntable.

At the beginning of this specification a mechanical device was mentioned by means of which the shaft of the distributor (see specification accompanying principal patent) could be disconnected when the motion picture apparatus should operate alone. With the driving device of the motion picture apparatus described in the specification accompanying the principal patent the operator always has to make the distributor operate (and consequently also the synchronizer attached to the gramophone) without removing the chain which transmits the movement to it even

when the scene is without sound. In order to eliminate this disadvantage the single bicycle pinion placed on the motion picture apparatus has been replaced by a pinion similar to free wheel pinions whose two parts (the movable part and the stationary part) can be made in one piece by means of a coupling when the starting is performed by hand. The crank, by means of which the motion picture apparatus is operated, is adjusted to the central part of this device whereas the other devices remain immovable.

Resumé

A flexible, elastic and readily separable joint connecting the axle of the synchronizing apparatus with the axle of the gramophone and essentially consisting of a helical spring connected on the one hand to the synchronizing apparatus and on the other hand terminating in an unsymmetrical fork whose arms engage in two holes made in the metal plate which drives the sound record, said joint having the effect of making the movement of the gramophone regular by eliminating the slight shocks due to the synchronizing apparatus.

A mechanical device, by means of which the motion picture apparatus can be released from the group of devices which control the synchronization, consisting of a free wheel pinion replacing the usual driving pinion.

OFFICE NATIONAL DE LA PROPRIÉTÉ INDUSTRIELLE.

BREVET D'INVENTION.

XII. — Instruments de précision, électricité.

2. — APPAREILS DE PHYSIQUE ET DE CHIMIE, OPTIQUE, ACOUSTIQUE.

N° 414.788

Installation pour la commande électrique des plateaux porte-disques dans les phonographes.

COMPAGNIE GÉNÉRALE DE PHONOGRAPHES, CINÉMATOGRAPHES ET APPAREILS DE PRÉCISION résidant en France (Seine).

Demandé le 13 avril 1910.

Délivré le 28 juin 1910. — Publié le 10 septembre 1910.

Les inconvénients des ressorts de barillet utilisés pour transmettre à l'arbre des phonographes à disques son mouvement de rotation, étant bien connus, on a tenté à diverses reprises de remplacer cette commande mécanique, un peu primitive, par une commande électrique. Mais de nouvelles difficultés se présentées, dues aux légères pulsations du moteur qui se traduisent dans une telle application par des mouvements plus ou moins saccadés du disque, rendant une bonne exécution impossible. Les diverses solutions préconisées pour remédier à ce dernier inconvénient conduisant à des dispositifs complexes ou coûteux, la commande électrique des phonographes à disques n'a pu, jusqu'ici, entrer dans le domaine de la pratique.

Cette invention a pour objet une installation pour la commande électrique de l'arbre des phonographes à disques, remarquable en ce qu'elle permet d'assurer au plateau, et par suite au disque, une rotation parfaitement régulière sans entraîner aucune complication mécanique, ni dépense appréciable.

Cette installation se résume dans la combinaison suivante qui est, comme on va le voir, d'une extrême simplicité : le petit moteur électrique est directement attelé sur l'arbre du phonographe à disques au moyen, par exemple, de deux poulies dont les diamètres sont dans un rapport convenable et d'une courroie, et le plateau porte-disque est lesté sur sa périphérie par l'adjonction d'une jante lourde venue d'une même pièce ou rapportée, laquelle fait office de volant pendant la rotation de l'arbre et suffit pour assurer la rotation régulière du plateau et du disque et pour supprimer les irrégularités d'exécution que provoquerait l'accouplement direct du moteur sur l'arbre d'un phonographe à plateau ordinaire.

Au dessin annexé, les fig. 1 et 2 représentent, à titre d'exemple, une vue en élévation et une vue en plan de l'installation suivant l'invention :

Les fig. 3, 4, 5 et 6 montrent, en coupe partielle trois variantes du plateau porte-disque pour une telle installation.

Sur la paroi inférieure *a* de la boîte du phonographe est fixée une plate-forme métallique *b* munie d'un bras *c* qui sert à supporter et guider l'arbre vertical *o* du phonographe. D'autre part, sur la paroi verticale *d* de la boîte est fixé, par son socle, un petit moteur électrique *m*, de telle manière que son arbre soit disposé verticalement. Une poulie à gorge *f*, de grand diamètre, est calée sur l'arbre *o* du phonographe et une poulie à gorge *g*, de petit diamètre, est calée, en regard

de la première, sur l'arbre du moteur. Une petite courroie à section ronde ou trapézoïdale relie entre elles les deux poulies.

Sur l'arbre *o* du phonographe repose comme d'ordinaire le plateau métallique *p* servant à porter le disque; mais ce plateau au lieu d'avoir une épaisseur uniforme, est lesté, à sa périphérie, par une sorte de jante *j* de même métal ou en métal plus lourd, en plomb par exemple.

L'installation est complétée par un petit régulateur de vitesse *k* et éventuellement par un lanceur mécanique du type connu, c'est-à-dire comportant un levier horizontal *l* terminé, d'un côté, par une poignée *n* et, de l'autre, par un secteur denté qui engrène avec un pignon cylindrique calé sur l'arbre *o*. Dans le cas où on emploie un tel lanceur, dans l'installation suivant l'invention, le levier *l* portera de préférence un doigt de contact qui formera le circuit du moteur dès qu'on procédera au lancement et qui interrompra le courant lorsqu'on le ramènera à sa position de repos.

La jante *j* du plateau porte-disque, destinée à former volant pendant la rotation de ce plateau, sera de préférence réservée sur le pourtour même dudit plateau et sur sa face inférieure, comme montré à la fig. 3; mais elle pourrait aussi être réservée sur la face supérieure du plateau, comme montré à la fig. 4 ou répartie au-dessus et au-dessous du plateau comme à la fig. 5.

Cette jante pourra être venue d'une même pièce avec le plateau, mais elle pourrait aussi être rapprochée, ce qui permettrait de la faire en métal plus lourd, en plomb par exemple.

Pour les disques qui ont un rebord décoratif *r* de même épaisseur que le plateau, comme montré à la fig. 6, la jante sera de préférence rapportée sous forme d'une rondelle lourde *j'* disposée en contact avec la surface interne de ce plateau, mais elle pourrait aussi être formée par une rondelle entourant extérieurement le plateau et son rebord.

L'invention pourrait, finalement, être réalisée en conservant le plateau usuel sans jante lourde et en constituant cette jante sur le pourtour du disque lui-même qui aurait à cet endroit une très forte surépaisseur, mais il va de soi que le système précédemment décrit est plus pratique et moins coûteux.

RÉSUMÉ.

Cette invention est relative à une installation pour la commande électrique des plateaux porte-disques dans les phonographes, consistant à atteler directement un petit moteur électrique sur l'arbre du phonographe à disques au moyen, par exemple, de deux poulies dont les diamètres sont dans un rapport convenable et d'une courroie, et à monter sur l'arbre du phonographe un plateau porte-disque lesté sur sa périphérie par l'adjonction d'une jante lourde venue d'une même pièce ou rapportée, laquelle fait office de volant pendant la rotation de l'arbre, une telle installation permettant, au moyen d'un groupement mécanique très simple et peu coûteux, d'assurer au phonographe à disques l'avantage de la commande électrique tout en supprimant complètement les irrégularités d'exécution que tendent à provoquer les légères pulsations du moteur électrique.

COMPAGNIE GÉNÉRALE DE PHONOGRAPHIES, CINÉMATOGRAPHES ET APPAREILS DE PRÉCISION.

Par procuration :

LAVOIX et MOSÈS.

N° 414.788 — Compagnie Générale de Phonographes, Cinématographes et Appareils de Précision — Pl. unique

FIG_1_

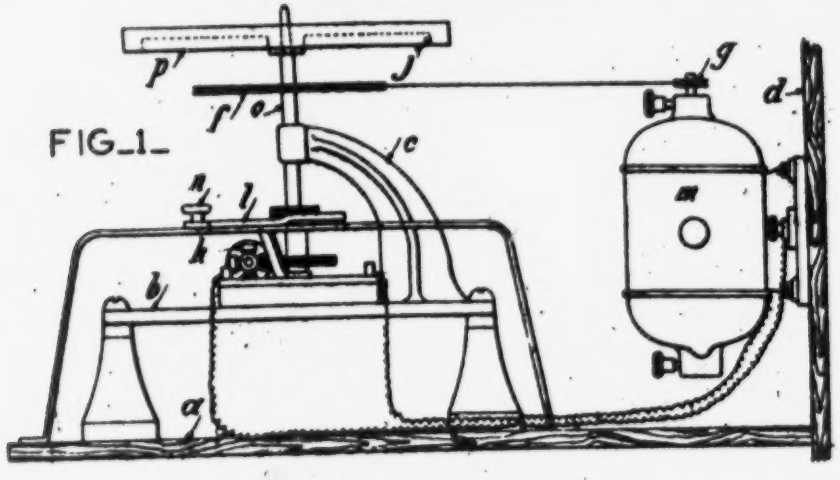


FIG_2_

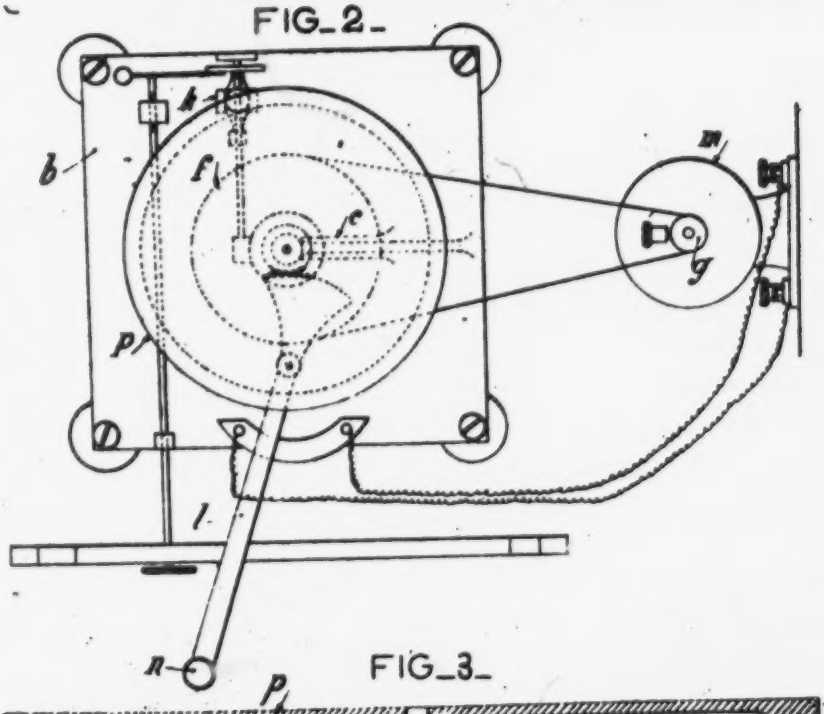


FIG_3_

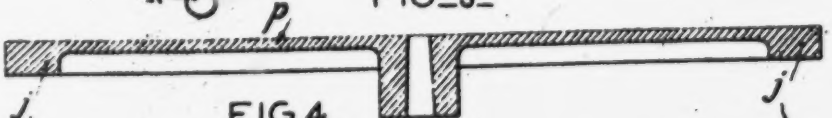
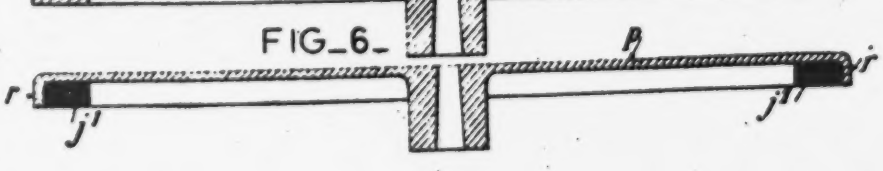


FIG_4_

FIG_5_

FIG_6_



Translation.

FRENCH PATENT No. 414,788, filed April 13, 1910, published September 10, 1910

Installation For The Electric Drive Of Turntables Carrying Disc Records In Phonographs

Compagnie Generale de Phonographes, Cinematographes et Appareils de Precision resident en France (Seine).

The inconvenience of using barrel springs for driving the shaft of disc type phonographs, being well known, various systems have been made to replace this mechanical driving which is somewhat primitive by an electrical drive, but new difficulties present themselves due to the gentle pulsations of the motor which translate themselves in such an application into more or less jerky movement of the disc thus rendering a good reproduction impossible. The various solutions presented to remedy this latter inconvenience lead to arrangements which are complex or costly and consequently an electric drive for disc type phonographs has not as yet been entered in the domain of practice.

The present invention has, however, for its object the installation of an electric drive on the shaft of a disc type phonograph distinguished by the fact that it allows the table in consequence the disc to be given a rotation which is perfectly regular without entailing any mechanical complication, or appreciable expense.

This arrangement is summed up in the following combination which is as one may see extremely simple: the little electric motor is directly connected to the shaft of the disc type phonograph for example by means of two pulleys whose diameters are in the proper ratio and provided with a leather belt, and the table is weighted at its periphery by the application

of a heavy rim which may be either integral or applied. This swiftly moving rim suffices to assure regular rotation of the table and disc and to suppress the irregularities of reproduction due to direct coupling of the motor to the shaft in an ordinary phonograph.

In the drawings, Figs. 1 and 2 represent, as shown, an elevation and a plan view of an arrangement according to the invention. Figs. 3, 4, 5 and 6 show in partial section 3 variations of the table for such an apparatus. On the baseboard a of the phonograph box is mounted a metallic platform b provided with an arm c which serves to support and guide the vertical shaft o of the phonograph. On the side wall d of the box is mounted a small electric motor m in such a way that its shaft is vertical. A curved pulley f of large diameter is keyed to the shaft o of the phonograph and a curved pulley g of small diameter is keyed on the shaft of the motor opposite the frame. A small leather belt of round or trapezoidal cross-sections runs over the two pulleys.

On the shaft o of the phonograph is positioned the customary metal table p which served to carry the disc; but this table instead of being of uniform thickness is weighted at its periphery by a kind of rim or felly j of the same metal or of a heavier metal, for example, lead.

The apparatus is completed by a little governor k and if necessary by a mechanical starter of a well known type, for instance, comprising a horizontal lever l terminated at one end by a handle n and at the other end by a tooth sector which engages with a cylinder pinion keyed to the shaft o. In case such a starter is used in combination with the invention, the lever l preferably carries a contact finger which closes the circuit of the motor when the supporter is moved forward and breaks the circuit when it is returned to its negative position.

The felly j of the table which forms a flywheel during the rotation of the table will be preferably positioned at the circumference of the table and against its lower face as shown in Fig. 3 but it might also be placed at the upper face of the table as shown in Fig. 4 or both down and up as shown in Fig. 5.

This felly can be in one piece with the table or it can be applied thereto which will permit it to be made of a heavier metal for instance of lead.

For tables which have an ornamental rim r of the same thickness as the table top as is shown in Fig. 6, the felly will preferably be applied in the form of a heavy ring j^1 positioned in contact with the interior surface of the table but it might also be formed as a ring surrounding the exterior of the table and its rim.

Finally, the invention might be employed by adopting the customary table without a heavy felly and positioning this felly about the circumference of the disc itself which would have in this respect a very large diameter; but it is evident that the system previously described is more practical and less costly.

Resumé:

This invention relates to an arrangement for an electric drive for the disc type of phonograph consisting in connecting a small electric motor to the shaft of the phonograph, for example, by means of two pulleys of which the diameters are in an adapted ratio and by means of a belt; and mounted on the shaft of the phonograph, a table weighted at its periphery by the provision of a heavy felly either integral or applied which has a function of being a fly-wheel during the rotation of the shaft, such apparatus assuring to the phonograph the advantages of an electric drive that will completely suppress irregularities of reproduction derived from gentle pulsations of the electric motor and all by means of a very simple and inexpensive mechanical arrangement.

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BREVET D'INVENTION.

XII. — Instruments de précision, électricité.

2. — APPAREILS DE PHYSIQUE ET DE CHIMIE, OPTIQUE, ACOUSTIQUE.

N° 472.467

Phonographe utilisant des bandes minces et flexibles comme support des phonogrammes.

Société DRAGOUMIS ET LIORET résidant en France (Seine).

Demandé le 10 avril 1914, à 13 heures, à Paris.
Délivré le 6 août 1914. — Publié le 8 décembre 1914.
(Demande de brevet déposée en Belgique le 6 août 1913. — Déclaration des déposants.)

L'appareil faisant l'objet de cette invention est un phonographe permettant d'employer pour l'enregistrement et la reproduction des bandes sans fin minces et flexibles de différentes longueurs et de différentes largeurs, en celluloïd ou autre substance quelconque appropriée. Comme ces bandes peuvent défiler à une vitesse très réduite et peuvent être enregistrées des deux côtés, la longueur de l'enregistrement contenu sur une bande, même de dimensions restreintes, peut être très considérable.

Le dessin annexé, donné à titre d'exemple, représente une forme d'exécution de l'invention. A ce dessin :

Fig. 1 est une vue en plan.

Fig. 2, une vue de côté de l'appareil.

Fig. 3, la disposition pour le guidage des bandes.

1 est un tambour cylindrique d'un diamètre plus grand et d'une longueur plus petite que le tambour du phonographe ordinaire, son axe tourne dans le bâti 2.

3, 3' est une perche articulée composée de deux ou de plusieurs parties. Cette perche passe dans un collier 4 où elle peut être rentrée ou sortie du bâti à volonté. La dernière partie 3' peut éventuellement être articulée sur une broche 5 qui l'engage dans un des trous 5 dont elle est pourvue. Ainsi, on peut employer des bandes de longueurs très différentes. Cette partie de la perche porte un rouleau 6 pivotant en 7, dont l'axe est une goupille qu'on peut retirer de la pièce 3'. Ce rouleau sert comme tendeur de la bande sans fin 8.

La disposition pour le guidage de la bande est composée d'une barre 10 fixée sur le socle de l'appareil, elle porte deux traverses 11 et 12. Le long de la traverse 12 glisse une joue mobile 13 qui peut être fixée par une vis de pression à une distance de la barre 10 égale à la largeur de la bande. Ainsi la bande 8 touche aux traverses arrondies 11 et 12 qui la maintiennent à plat et ne peut pas dévier maintenue entre 10 et 13.

Un indicateur montre les points où l'enregistrement ou le reproducteur touchent la bande. Cet indicateur est composé d'un tambour étroit 14 portant des divisions sur son pourtour. Les divisions de ce tambour qu'on tourne au moyen d'une manivelle 15 sont montrées par l'aiguille fixe 16. Un compteur 17 divisé de 0 à 9 marque le nombre des tours du tambour qui est engrené par des roues dentées avec la vis du chariot 18. Ainsi, quand le chariot se déplace, son déplacement est indiqué par l'indicateur, et on

peut ramener le chariot au point voulu en tournant la manivelle 15, le levier 19 sert à soulever l'enregistreur ou le reproducteur sans que le chariot cesse d'engrener avec la vis, ainsi est évité tout jeu résultant d'un enclenchement ou d'un déclenchement. La vis du chariot n'est pas solidaire de l'engrenage de réduction mais elle se laisse enclencher et déclencher sans aucun jeu au moyen des disques à friction 20. Quand ces disques ne se touchent pas, la vis est indépendante, quand par conséquent on ramène le chariot au point voulu en tournant la manivelle 15, le tambour 1 qui entraîne la bande 8 reste immobile. On peut ainsi pendant l'enregistrement ou pendant une reproduction, écrire une table de matières, comme pour un livre, où les numéros des pages seront remplacés par les numéros de l'indicateur. Cette table peut être en caractères en relief pour l'usage des aveugles dans ce cas les divisions de l'indicateur peuvent être aussi rendus sensibles au toucher.

24 est une butée quand le chariot touche à cette butée, l'indicateur 14 et le compteur de tours 17 doivent être à 0.

L'engrenage qui transmet le mouvement du tambour 1 à la vis du chariot peut être rendu interchangeable au moyen d'un dispositif connu. Ainsi on peut avoir par exemple deux ou trois rapports de réduction de tours correspondants à deux longueurs différentes de bandes. Mais si on a à employer des bandes d'un plus grand nombre de longueurs différentes, on peut employer les boîtes à engrenages décrites dans le brevet belge 245.606 du 16 avril 1912.

RÉSUMÉ.

L'invention concerne :

Un appareil phonographique permettant l'emploi des bandes sans fin minces et flexibles, de différentes longueurs et de différentes largeurs, comme support des phonogrammes, caractérisé par :

1° Une perche articulée dont la partie d'avant porte un rouleau tendeur et qui permet l'emploi de bandes de différentes longueurs;

2° Un guide pour les bandes comportant une joue fixe et une joue mobile qui empêchent la bande de dévier et deux traverses arrondies qui la maintiennent à plat, le guide permettant l'emploi de bandes de différentes largeurs;

3° Un indicateur de la position de l'enregistreur ou du reproducteur engrenant avec la vis du chariot, et qui peut ramener le chariot au point voulu.

SOCIÉTÉ DRAGOUMIS ET LIORET.

Par procuration :

G. PETIET.

N° 472 467 Société Dragoumis et Luret Pl. unique

Fig. 1.

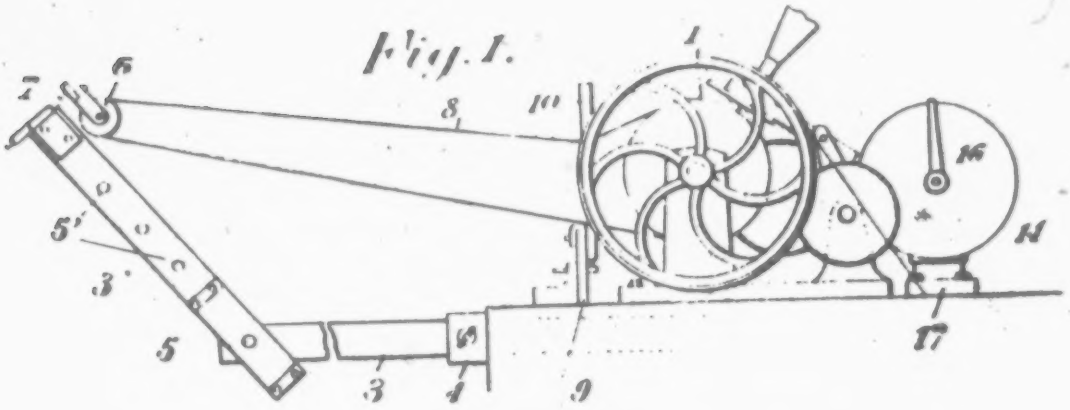


Fig. 2.

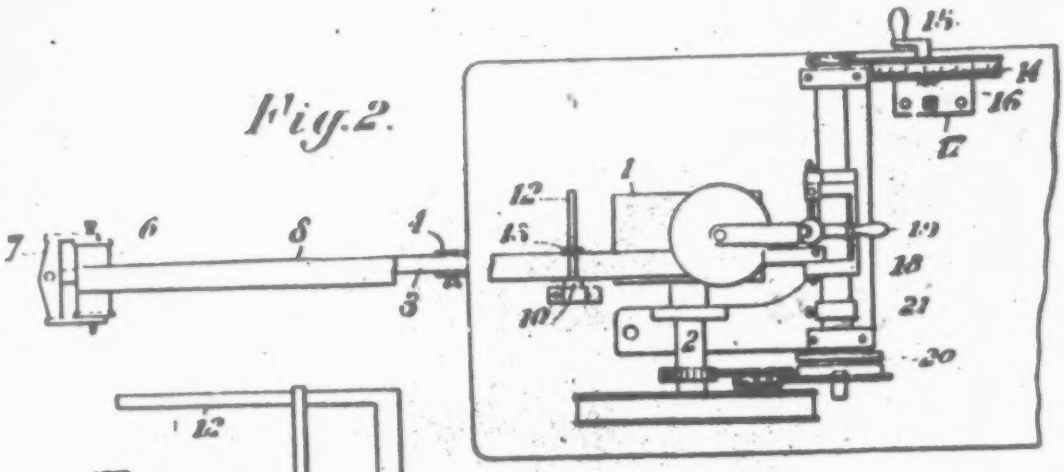
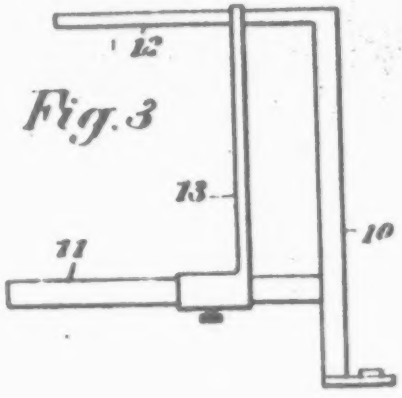


Fig. 3



Translation.

FRENCH REPUBLIC

FRENCH TRADEMARK AND PATENT OFFICE

Patent of Invention.

No. 472,467

XII.—Instruments of Precision—Electricity.

2.—Apparatus for physics, chemistry, optics and acoustics.

Phonograph utilizing thin and flexible bands or films as phonogram supports.

Messrs. DRAGOUMIS & LIORET Co., residing in France (Seine).

Patent applied for on April 10, 1914, at 1 P. M., at Paris.

Issued on August 6, 1914—Published on December 8, 1914.

(Patent applied for in Belgium on August 6, 1913—Declaration of the applicants.)

The apparatus which is the subject matter of this invention is a phonograph, which makes it possible to use, for the recording and the reproduction, thin and flexible endless bands or films of various lengths and widths made of celluloid or any other suitable material. As these bands can pass at a very reduced speed and may be recorded on both sides, this makes it possible to obtain a very considerable length of recording on one single band, even if such band is of small dimensions.

The attached drawing shows, by way of example, one manner of embodiment of the invention. In this drawing:

Fig. 1 is a plane view of the apparatus.

Fig. 2 is a side view of the apparatus.

Fig. 3 shows the arrangement for the guiding of the bands.

1 is a drum of cylindrical shape and of a larger diameter and a smaller length than those of the drum of an ordinary phonograph; its shaft rotates in the frame 2.

3 is an articulated rod made of two or more parts. This rod passes through a collar 4 and may be pushed in or out of the frame at will. The last part 3′ of this rod may possibly be articulated on and connected with a spindle 5, which is made to engage into one of the holes 5 arranged on same. It is thus possible to use bands of greatly varying lengths. This part of the rod carries a roller 6 which pivots at 7 and the shaft of which constitutes a pin which may be removed from part 3′. This roller serves as a stretching device for the endless band or film 8.

The arrangement for the guiding of the band or film is made of a bar 10 attached in a fixed position to the base of the apparatus. It carries two cross-members 11 and 12. Along the cross-member 12, there slides a movable cheek or flange 13, which may be fixed by means of a set screw, at a distance from bar 10 equal to the width of the band or film. In this manner, the band 8 touches the cross-members 11 and 12, which have been rounded, and which hold the band or film flat so that the band cannot deviate or run out of true as it is firmly held in position between 10 and 13.

An indicator shows the points where the recording device or the reproducing device touch the band. This indicator is made of a narrow drum 14, the periphery of which is graduated. The graduations of this drum, which is caused to rotate by means of a crank, 15, are shown by the fixed hand 16. A counter

17, divided from 0 to 9, indicates the number of rotations of the drum which is engaged, by means of sprocket wheels, with the screw of the carriage 18. In this manner, when the carriage moves, its displacement is shown by the indicator, and the carriage can be brought back to any desired point by turning the crank 15. The lever 19 is used to raise the recording or reproducing device without the carriage being disconnected from the screw; this eliminates all play that might be caused by engaging or disengaging the carriage. The carriage screw is not integral with the reduction gear, but it may be engaged and disengaged without any play whatever by means of friction discs 20. When these discs do not touch one another the screw is independent; consequently when the carriage is brought back to the desired point by turning the crank 15, the drum 1, which drives the band or film 8, remains stationary. It is thus possible, during the recording or the reproduction, to draw up an index, as is done in books, replacing the page numbers by the numbers of the indicator. Such an index may be printed with embossed type for the blind, and in this case the graduations of the indicator may also be made in such a manner as to be felt by touch.

21 is a thrust and when the carriage touches this thrust, the indicator 14 and the counter 17, which counts the number of revolutions, must be at 0.

The gear transmitting the motion of the drum 1 to the carriage screw may be rendered interchangeable by means of a device already known. Thus, one may have two or three R. P. M. Gear Ratios corresponding to two different lengths of bands or films. However, if one must use bands of a greater number of different lengths, then one may use gear boxes like those described in the Belgian patent #245,606 of April 16, 1912.

CLAIMS

This invention concerns:

A phonographic apparatus which makes it possible to use thin and flexible endless bands or films, of various lengths and widths, as phonogram supports, which apparatus is characterized by the following:

1. An articulated rod, the front part of which carries a stretching roller, which makes it possible to use bands or films of different lengths.

2. A guide for the bands or films, with a stationary cheek or flange and a movable cheek or flange preventing the band or film from deviating or running out of true, and two rounded cross-members maintaining the band flat. This guide makes it possible to use bands or films of different widths.

3. An indicator showing the position of the recording or reproducing device, engaging with the carriage screw, and making it possible to bring the carriage back to any desired point.

Messrs. DRAGOUMIS & LIORET Co.,
by: G. Petiac,
Agent.

KAISERLICHES PATENTAMT.

AUSGEGEBEN DEN 15. JUNI 1903.

PATENTSCHRIFT

№ 141634

KLASSE 42g.

ELIAS KHER IN CAIRO (ÄGYPTEN).

Phonograph mit Walze und über diese laufendem endlosen Bande.

Patentiert im Deutschen Reiche vom 8. Juli 1902 ab.

Gegenstand der Erfindung ist ein Phonograph mit einem endlosen Band aus Celluloid oder ähnlichem Material und kennzeichnend für sie ist im wesentlichen die neue Art des Verzeichnens der Tonschwingungen.

In der Zeichnung ist die Erfindung an einem Ausführungsbeispiel erläutert.

Fig. 1 ist eine perspektivische Ansicht des Phonographen mit den Vervollkommnungen gemäß der Erfindung in ausgezogenen Linien, während die beibehaltenen Teile in punktierten Linien dargestellt sind.

Fig. 2 ist ein senkrechter Querschnitt durch den Bandträgerzylinder.

Fig. 3 ist eine teilweise Vorderansicht des Phonographen.

Die Bänder *a* aus Celluloid werden aus sehr biegsamen Blättern gearbeitet, der Breite des Zylinders des Phonographen entsprechend geschnitten und dann an ihren Enden verbunden, und zwar so, daß sie auch dort biegsam und glatt sind, so daß sie endlose Bänder mit beliebig groß zu wählender Abwicklungsfläche bilden.

Die Bänder sind an ihren beiden Rändern mit Löchern versehen, die ihrer Mitnahme durch eine geeignete Antriebsvorrichtung dienen.

An dem einen Rand der Bänder *a* ist ein Streifen *b* aus beliebigem elastischen Stoff befestigt, genau von der Länge des Abwickelungsumfanges der Transportschraube *v* für die Bewegung der Phonographenmembran.

Die endlosen Bänder *a* bilden die Unterlage für das Einzeichnen der Tonschwingungen auf ihren beiden Seiten, in einer Reihe von Rillen, die nebeneinander parallel zu den Rändern des Bandes verlaufen und so eine unterbrochene Rille von dem einen Bandrand zum anderen bilden.

Um dies zu erreichen, wird z. B. der Edison'sche Phonograph wie folgt ausgebildet.

An dem Kern *d* ist ein zylindrischer Mantel *e* aus isolierendem Material, z. B. Ebonit, aufgesetzt, zwischen dessen vorspringenden Rändern *f* genau passend das endlose Band *a* liegt. Stifte *g* greifen nahe den Rändern *f* in die Bandlöcher ein, um die genaue Mitnahme zu sichern. Seitlich des Mantels *e* sind zwei (vorteilhaft mit Kautschuk bekleidete) Rollen *h h* angeordnet, die durch Federn das Band *a* an dem Mantel *e* genau anlegen. An dem Ende des Mantels *e*, wo sich die Transportschraube *v* befindet, ist ein Halter *i* am Phonographengehäuse befestigt, der zwei gegenseitig isolierte übereinander angeordnete Blattfedern *j* und *k* trägt.

Die obere Feder *j* federt weniger und ist mit einer Stellschraube *l* zur Regelung des Abstandes des freien Endes der oberen von dem der unteren Feder *k* versehen. An die Feder *j* ist der eine Leitungsdraht angeschlossen. Die untere Blattfeder *k* trägt am Ende eine geründelte Rolle *c*, die sich auf den Rand des Bandes *a* in der Bahn des Streifens *b* legt. Über der Rolle *c* trägt die Feder *k* einen Kontaktknopf, der mit der oberen Feder *j* in Berührung kommt, sobald bei der Umdrehung des Kernzylinders *e* der vorstehende Streifen *b* die Rolle *c* anhebt.

Die Feder *j* steht durch einen Leitungsdraht mit einem Elektromagneten *n* in Verbindung, der an der Hülse *q* des Membranträgers befestigt ist. Unter dem Elektromagneten *n* liegt

141,634

der Anker *o*, der an dem einen Ende eines Hebels *p* befestigt ist, der seinen Drehpunkt an dem Elektromagneten hat, und an dem anderen Ende die Eingriffsklaue *m* trägt, die sich unter dem Gewicht des Ankers *o* in der Regel außer Eingriff mit der Transportschraube *v* befindet.

Bei jedem vollständigen Umlauf des Bandes *a* und infolgedessen stattfindendem Anheben der Rolle *c* durch den Streifen *b* wird der Strom durch den Federkontakt *j k* geschlossen, der Elektromagnet *n* hebt Anker *o* des Hebels *p* und die Eingriffsklaue *m* kommt mit der sich drehenden Transportschraube *v* in Eingriff.

In diesem Augenblick wird daher der vorher stillstehende Membranträger vorgeschoben und die Membrannadel rückt um eine Ganghöhe des Transportschraubengewindes weiter, bis der Streifen *b* die Rolle *c* verläßt und der Strom unterbrochen ist.

Die Eingriffsklaue *m* ist dann ausgerückt, und die Membran steht wieder still, die Nadel zieht daher die nächste Rille parallel der vorigen, bis das Band wieder einen vollen Umlauf mit dem Mantel *c* vollendet hat und der Streifen *b* die Rolle *c* anhebt.

Zum Zweck des besseren Anhaftens des Bandes *a* auf dem Mantel *c* läßt man dieses durchhängen und legt zwischen seine beiden Züge eine mit Rändern versehene Rolle *r* als Gegengewicht ein.

In den Fällen, wo sich das Ende des Phonographen mit dem Zylinder nicht über einem freien Raum anordnen läßt, können die Ecken des Tisches bezw. des Gehäuses, auf dem der Phonograph angeordnet ist, mit Führungsrollen versehen werden, die das Band, ohne daß es sich beim Umlaufen reibt, über den Tisch bezw. das Gehäuse hinweg führen.

Der Stromschluß kann auch in der Weise erfolgen, daß der Streifen *b* durch eine Öffnung von gleicher Länge in dem Band *a* ersetzt wird. Ein an dem Zylinder angeordneter Metallring, der mittels Gleitbürste mit dem einen Leitungsdraht in Kontakt steht, stellt dann Stromschluß her, wenn die mit dem anderen Leitungsdraht verbundene Rolle auf die Öffnung des Bandes trifft und den Metallring berührt. In diesem Falle fällt die Blattfeder *j* fort, und der an diese angeschlossene Draht wird an die Gleitbürste angeschlossen.

Eine weitere Ausführungsform wäre die, daß der vorstehende Streifen *b* aus Isoliermaterial durch einen Metallstreifen ersetzt wird, der genügend elastisch ist, und zwei gegenseitig isolierte Kontaktrollen nebeneinander angeordnet werden, die in der Bahn des Metallstreifens auf dem Bande *a* laufen und jede mit einem Leitungsdraht verbunden sind, so daß, wenn der Metallstreifen mit den Rollen in Berührung kommt, diese leitend verbunden werden und der Strom geschlossen wird.

Es ist bei Phonographen mit unter dem Membranstift absatzweise parallel hin- und herbewegten Platten bekannt, die Übergänge zwischen den parallelen Rillenlinien durch kurze Bögen zu verbinden, indem während des Richtungswechsels ein zeitweises Weiterschalten der Membran durch Drehen der Transportschraube stattfindet. Diese kurzen Übergangsbögen haben aber den Nachteil, daß bei enger Stellung der Parallellinien der Übergang zu schroff wird bezw. bei genügend großen Bögen der Raum durch Weiterstellung der Parallellinien ungenügend ausgenutzt wird, und weiter beeinträchtigt die Umkehr der Bewegungsrichtung die Anwendbarkeit im Winkel gegen die Bewegung der Zeichenflächenbewegung gestellter Schneidstifte, während bei dem allmählichen Übergang der in gleicher Richtung bewegten Parallellinien durch Schraubenlinien gemäß der vorliegenden Erfindung auch auf dieser Übergangsstrecke die Schraubenlinien nur unmerklich von der Parallelen abweichen.

Patent-Ansprüche:

1. Phonograph mit Walze und über diese laufendem endlosen Bande aus Celluloid oder ähnlichem Material, auf dem die Tonschwingungen in auf dem größten Teil der Strecke parallelen Linien verzeichnet werden, dadurch gekennzeichnet, daß die Übergänge zwischen den parallelen Strecken der fortlaufenden Rille durch als Schraubenlinien verlaufende Strecken erfolgen, die durch einen bei jedem Umlauf des endlosen Bandes einmal erfolgenden absatzweisen Transport der Membran ohne Umkehr der Drehungsrichtung hergestellt werden.

2. Ausführungsform des unter 1. gekennzeichneten Phonographen, dadurch gekennzeichnet, daß das absatzweise Transportieren der Membran zum Erzeugen der schraubenlinienförmigen Verbindungsstrecken dadurch erfolgt, daß ein Stromkreis, welcher mit Hülfe eines Elektromagneten den Membranträger mit der Transportschraube in Verbindung hält, einmal bei jeder Umdrehung des endlosen Bandes durch eine am Rande desselben befindliche Kontaktvorrichtung für die Zeit geschlossen wird, während welcher der Membranträger bewegt werden soll.

Hierzu 1 Blatt Zeichnungen.

BERLIN. GEDRUCKT IN DER REICHSDRUCKEREI.

ELIAS KHER IN CAIRO (ÄGYPTEN).

Phonograph mit Walze und über diese laufendem endlosen Bande.

FIG. 1.

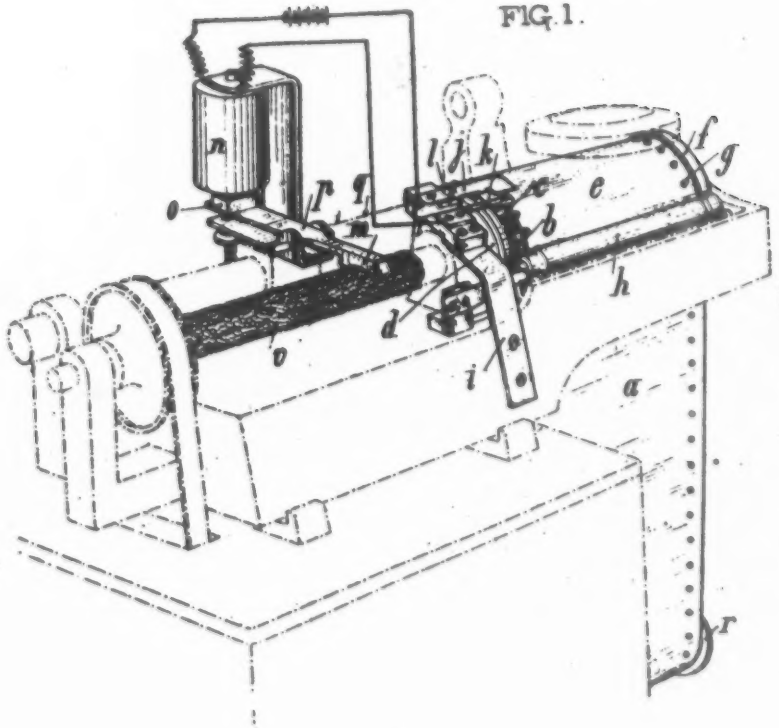


FIG. 2.

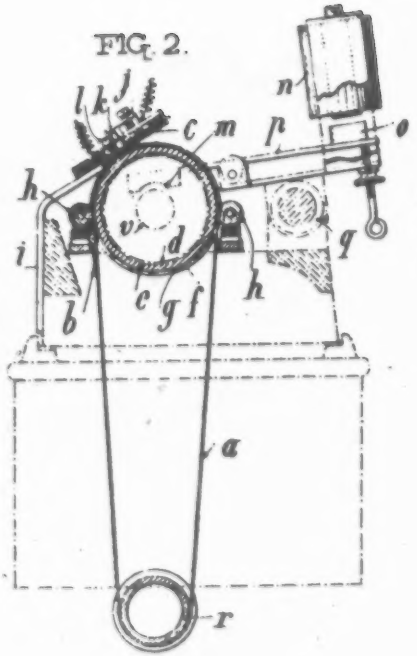
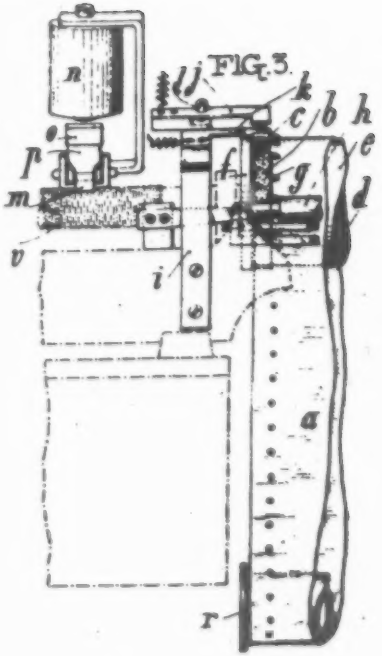


FIG. 3.



Zu der Patentschrift

№ 141634.

- PHOTOGR. DRUCK DER REICHSDRUCKEREI.

1389

Translation.

GERMAN No. 141634.

Elias Kher in Cairo (Egypt)

Phonograph With Cylinder And Endless Band Running On Said Cylinder.

Patented in Germany from July 8, 1902; granted June 15, 1903.

The object of the invention is a phonograph having an endless band of celluloid or similar material. An essential feature of the invention is the novel method of recording sound vibrations.

The drawing illustrates an example of the construction.

Fig. 1 is a perspective view of the phonograph with the improvements of the invention shown in full lines, while the conventional [retained] parts are shown in dotted lines.

Fig. 2 is a vertical cross section thru the band carrier cylinder.

Fig. 3 is a partial front view of the phonograph.

The celluloid bands "a" are made of very flexible sheets cut corresponding to the width of the phonograph cylinder and then joined at their ends in such a way that they are also then flexible and smooth so that they form endless bands chosen of any desired large area.

The bands are provided with perforations near both edges which serve for progressing them by means of a suitable driving mechanism.

At one edge of the bands "a" is attached a strip "b" of any desired elastic material having exactly the circumferential length unrolled by [one turn of] the feed screw "v" which serves for moving the phonograph diaphragm.

The endless bands "a" form a support for the recording of the sound oscillations on both of their sides, in a series of grooves which are side by side and run parallel to the edges of the band and so form an uninterrupted groove from one band edge to the other.

To realize the foregoing an Edison phonograph is modified as follows:

On the mandrel "d" is placed a cylindrical sleeve "e" of non-conducting material, (such as for example EBONITE). Between whose raised flanges "f" which fit the film closely is laid the endless band "a". In order to ensure correct travel of the band, pins "g" located close to flanges "f" engage in perforations of the band.

Laterally to sleeve "e" are located two rollers "hh" (advantageously covered with rubber) which by means of springs accurately press the band "a" into contact against the sleeve "e". At the end of sleeve "e" where the feed screw "v" is located is a holder "i" which is attached to the phonograph housing and which carries two flat springs "j" and "k", insulated from each other and located one above the other.

The upper spring "j" is less springy and is provided with an adjustment screw "l" for adjusting the distance between the free end of the upper spring from the lower spring "k". An electrical connection is made to the spring "j". The lower flat spring "k" carries on its end a knurled roll "c" which is positioned on the edge of the band "a" in the path of the strip "b". Over the roll "c" the spring "k" has a contact point which touches the upper spring "j" as soon as, on account of rotation of mandrel "e", the raised strip "b" lifts the roll "c".

The spring "j" is connected by a wire to an electromagnet "n" which is fastened to the guide sleeve "q" of the diaphragm carrier. Under the electromag-

net "n" is the armature "o" which is fastened to one end of the lever "p" having its pivot on the electromagnet. The other end of the lever carries the feed nut "m", which is normally out of engagement with the feed screw "v" due to the weight of armature "o".

At each complete revolution of the bands "a" and consequent lifting of roller "c" by strip "b" a circuit is closed thru spring contact "jk". The electromagnet "n" lifts armature "o" of lever "p" and feed nut "m" engages in the revolving feed screw "v".

At this instant the diaphragm carrier which has been at rest up to this moment is moved and the diaphragm stylus advances by one pitch length of the feed screw thread until the strip "b" leaves the roller "c" and interrupts the current.

The feed nut "m" is then disengaged and the diaphragm again stands still. The stylus records therefore the next groove parallel to the previous one until the band with sleeve "e" completes a full revolution and strip "b" lifts roller "c".

In order to obtain better adhesion of band "a" on sleeve "e" the endless band is allowed to hang down weighted by a flanged roller "r".

In those cases where it is not possible to have the phonograph located over a free space the corners of the table or of the housing on which the phonograph rests may be provided with rollers which guide the band without friction while in motion over the table or housing.

The electrical circuit may also be closed by an opening in the band corresponding to the length of the raised strip "b". A metal ring on the mandrel makes contact with a trailing brush and closes the circuit thru the roller "c" when it touches the metal ring. In this case the flat spring "j" is eliminated and the wire attached to it is connected to the trailing brush.

A further form of construction would be as follows: The non-conducting strip "b" is replaced by a metal strip which is sufficiently elastic to make contact with two insulated rollers arranged side by side. These rollers are in the path of the metal strip on the band "a" and each one is connected by a conducting wire, so that the circuit is completed when the metal strip contacts with the two rollers.

Phonographs are known in which a record plate is moved under the stylus back and forth in parallel lines, the transition from one parallel groove to another being made by short arcs. This is done by periodically advancing the diaphragm carrier during change of direction by means of a feed screw. These short transition arcs have however the disadvantage that with a close spacing of the parallel grooves the transition is too abrupt. Again if the arcs are large and the parallel grooves widely separated the recording area is insufficiently utilized. Furthermore this method of reversing the direction has the drawback that an inclined position of the stylus in the direction of motion cannot be used. According to the method of the present invention where the direction of motion is not changed the deviation in direction of the helical transition grooves from the parallel grooves is very small.

CLAIMS.

1. A phonograph with a cylinder and an endless band of celluloid or similar material running over same, having sound oscillations recorded in parallel lines on the greater portion (stretch) of the band, characterized thereby that the transition between the parallel stretches of the continuous grooves are made by stretches following a helical course and these latter stretches being produced at every revolution of the endless band by an intermittent feed of the diaphragm without reversal of rotation of direction.

2. Form of construction according to claim 1 characterized thereby that the intermittent feed of the diaphragm for producing the connecting stretches in the form of helical lines by completing an electrical circuit and an electromagnet and thereby coupling the diaphragm carrier with the feed screw once at every revolution of the endless band and for the length of time during which the diaphragm carrier shall be moved by a contact arrangement located at the edge of the band.

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Blake "Lion and Eagle" Imp'd Crusher, See p. 380.

Gardiner's Pat. Belt Clamp. See Illus. adv., p. 380.

For best Duplex Injector, see Jenks' adv., p. 380.

The Twin Rotary Pump. See adv., p. 380.

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Telegraph, Telephone, Elec. Light Supplies. See p. 380.

For Pat. Safety Elevators, Hoisting Engines, Friction Clutch Pulleys, Cut-off Coupling, see Frisbie's ad. p. 380.

Tight and Slack Barrel machinery a specialty. John Greenwood & Co., Rochester, N. Y. See Illus. adv. p. 381.

Elevators, Freight and Passenger, Shafting, Pulleys and Hangers. L. S. Graves & Son, Rochester, N. Y.

For the manufacture of metallic shells, cups, ferrules, blanks, and any and all kinds of small press and stamped work in copper, brass, zinc, iron, or tin, address C. J. Godfrey & Son, Union City, Conn. The manufacture of small vises, notions, and novelties in the above line, a specialty. See advertisement on page 381.

Gear Wheels for Models (list free); Experimental Work, etc. D. Gilbert & Son, 213 Chester St., Phila., Pa.

Gould & Eberhardt's Machinists' Tools. See adv., p. 381.

Safety Boilers. See Harrison Boiler Works adv., p. 381.

The McGart Pat. Wrought Iron Pulley. See adv., p. 381.

For Heavy Punches, etc., see illustrated advertisement of Hilles & Jones, on page 381.

Steam Engines: Eclipse Safety Sectional Boiler. Lambertville Iron Works, Lambertville, N. J. See ad. p. 381.

Mineral Lands Prospected, Artesian Wells Bored, by Pa Diamond Drill Co. Box 688, Pottsville, Pa. See p. 381.

Lathes, Planers, Drills, with modern improvements. The Pratt & Whitney Co., Hartford, Conn.

For best low price Planer and Matcher and latest improved Sash, Door, and Blind Machinery, Send for catalogue to Bentley & Hermanson, Williamsport, Pa.

Ballstone Mat. Co.'s Wood Working Mach'y ad. p. 380.

The only economical and practical Gas Engine in the market is the new "Otto" Silent, built by Schleicher, Schumm & Co., Philadelphia, Pa. Send for circular

Ore Breaker, Crusher, and Pulverizer. Smaller sizes run by horse power. See p. 381. Totten & Co., Pittsburg.

Notes and Queries

HINTS TO CORRESPONDENTS.

No attention will be paid to communications unless accompanied with the full name and address of the writer.

Names and addresses of correspondents will not be given to inquirers.

We reserve our request that correspondents, in referring to former answers or articles, will be kind enough to name the date of the paper and the page, or the number of the question.

Correspondents whose inquiries do not appear after a reasonable time should repeat them. If not then published, they may conclude that, for good reasons, the Editor declines them.

Persons desiring special information which is purely of a personal character, and not of general interest, should remit from $1 to $5, according to the subject, as we cannot be expected to spend time and labor to obtain such information without remuneration.

Any numbers of the Scientific American Supplement referred to in these columns may be had at this office. Price 10 cents each.

(1) L. H. asks for a good method of waterproofing cloth. A. Saturate the fabric with a strong hot aqueous solution of soap, press out excess, and transfer to a second bath consisting of a strong aqueous solution of sulphate or acetate of alumina or acetate of lead, for several hours. Repeat if necessary, press out excess of liquid, and dry, not too rapidly, in the air.

(2) J. M. asks for a reliable receipt for violin varnish. A. Coarsely powdered copal and glass, each 4 oz.; alcohol, 64 o. p., 1 pint; camphor, ½ oz.; heat the mixture, with frequent stirring in the water bath so that the bubbles may be counted as they rise, until solution is complete, and when cold decant the clear portion. When all varnish is used it is made as for artists' virgin copal.

(3) E. R. J. asks how to make a large number of copies of manuscript in black ink. A. Try the following: Use the gelatine pad made with a large proportion of glue. Soak writing paper in clean water to saturation and dry carefully. Write with any ink on the prepared paper, and use as in the gelatine pad process; the parts of the gelatine surface not protected by the ink will be affected by the alum so as to leave a stencil which can be used by inking with a roller as in the electric pen process.

(4) A. R. T. asks how to proceed to bleach gutta percha. A. Dissolve the gutta percha in benzy (same in weight of boiling benzole, add to the solution plaster of very good quality, and agitate the mixture from time to time. By repeating for two days the plaster is deposited and carries down with it all the impurities of the gutta percha insoluble in benzole. The soln. we should not remove it, but drive the grease upon the clean portion of the cloth. It is, therefore, necessary to distribute the benzole first over a circle surrounding the grease spot, to approach the latter gradually, of the same time having blotting paper in contact with the spot to absorb the fat immediately. Another method, namely, to apply a hot iron on one side while blotting paper is applied to the other, depends upon the fact that the surface tension of a substance diminishes with a rise of temperature. If, therefore, the temperature at different portions or sides of the cloth is different, the fat acquires a tendency to move from the hotter parts toward the cooler.

(5) E. N. B. writes: My main shaft runs 65 revolutions per minute. I want to belt on to a counter shaft and from there to a pulley 12 inches in diameter, which must run 300 revolutions per minute. I want to know the diameter of the pulley on the main shaft, also of three on the countershaft. What is the simplest rule you know of for figuring this? A. Your 12 inch pulley is to make 300 revolutions per minute. You can assume such diameter of the driving pulley on the countershaft as best suited for the work, say 30 inches; this will give the speed of the counter shaft one-fifth, or 160 revolutions per minute. You have now the speed of the countershaft 160 revolutions per minute and the driving shaft 65 revolutions per minute; the two pulleys must have the same proportion. If we assume the countershaft pulley 30 inches diameter, we then have 65 : 160 :: 30 : diameter of driving pulley $= \frac{160 \times 30}{65} = 36.5$ inches. So the driving pulley will be 36.5 inches on to 30 inches and 60 inches on countershaft, driving 12 inches.

(7) J. M. writes: 1. I have four coils, one gallon each, of Fuller's battery, as described in Scientific American Supplement, No. 187. Fig. 32, and I want to magnetize some compass needles. Please tell me the size of magnet required to revive speed with the battery. A. Use soft iron core, five-eighths of an inch in diameter 8 inches long, and wind with six to eight layers of No. 18 wire. 2. How is the magnetizing of compass needles done? A. By placing them against the poles of the electromagnet or by rubbing them on a permanent magnet. 3. Is my battery large enough for such work? A. Yes. 4. Is there any difference in lifting power of two magnets, both of the same size of core, same size of wire, and both having the same number of layers, one magnet being made like the letter U, the other being made in three pieces with a yoke? A. No, providing the yoke in the latter case is well fitted to the cores. 5. Which is the best, to dissolve the bichromate of potash in warm water before putting it in the cell, or to put in the crystals? A. It is best to make a good solution and pour it into the cell. 6. Is there any objection to mixing a solution of bichromate of potash with sulphuric acid, if mixed when the solution is warm? A. The acid should not be added until the solution cools. 7. Is it unhealthy to sleep in a room where Fuller's batteries are used? A. There is no special danger if the room is well ventilated; it is better, however, to not have them in the bedroom. 8. How long will carbons last in the Fuller battery? A. If they are properly prepared they should last indefinitely. 9. Will my battery work on board of a vessel at sea as well as on shore? A. Yes, providing you can keep the solutions from spilling or mixing. 10. In winding a magnet does it make any difference if I wind the core with a separate piece of wire and connect the inner ends after winding, or wind the two cores with one piece of wire? A. It makes no difference. 11. Do compass needles lose their power in course of time? A. Not generally; they may, however, under certain conditions.

(8) A. B. P. asks: What book will I want for instructions and what materials will I want to make assays for gold and silver, as I am going to New Mexico, and expect to mine, prospect, and assay? A. See article on assaying in No. 91, current volume. Consult Bickell's "Assaying and Assay Schemes."

(9) W. McK. B. asks: 1. Which is better for cemetery purposes, American or Italian marble? A. Some of the hard (clay) Pennsylvania stones last much longer than Italian marble. 2. Is there machinery made for working sand to make glass? What is the cheapest and best method of screening sand for above purposes? A. Yes. See "Glass" and "Screens," Knight's "Mechanical Dictionary."

(10) W. E. J. asks: 1. How is vulcanized rubber acted on by sulphuric, nitric, and muriatic acids? Does it lose its properties? A. The dilute acids scarcely affect hard rubber or vulcanite; the undiluted acids, especially nitric and sulphuric, attack and decompose it. 2. Is there any metal or other substance suitable for making pens that is not destroyed by these acids? A. Gold pens are not affected by these acids (pens when used singly.

(11) C. E. R. writes: 1. I have one pound of No. 18 coated copper wire, and wish to construct an Ruhmkorff induction coil on the plan of the one described in Supplement, No. 180? A. Yes. Fuller directions given in Supplement, No. 180. 2. How large a condenser shall I use? Also how many quart cells Grenet? A. About 36 square feet of condenser surface and three to four cells of battery. 3. Will a two-quart cell, Grenet, consisting of one zinc and four carbon plates and broken, 9. I have made one which I think ought to work, but does not give such results as I expected. I used, as in original direction, seven layers of No. 16 on field magnet and No. 18 in armature. I turned soon to measure the resistance of each and also its current. Should the wire of the field magnet be wound in separate layers so as to join up in series or not as required? A. Yes. 8. I made the armature of cast iron, but propose to make one of soft wrought iron. A. You will probably get better results with wrought iron.

(14) A. W. S. asks: Can you tell me of any simple method by which I may determine whether water is hard or soft? A. Dissolve half an ounce of good white soap in a pint of hot rain water, let it cool and settle, and mix about an ounce of this with a pint of the water to be tested and let it stand a few minutes. If the water is soft it will remain clear. If hard it will become opalescent. 2. Is there any way to render rain water wholesome for cooking purposes without the use of a water filter? A. Put a few buckets of coarsely granular, well burned charcoal, free from dust, into the reservoir. 3. Where can I obtain a water filter? A. See column of Business and Personal.

(15) O. S. asks: 1. Will not a cylinder made of heavy sheet brass, three-sixteenths of an inch thick, brazed together with the two end pieces, turned in and turned up true and the thread cut on it, do as well if left hollow as a solid iron cylinder? A. The hollow cylinder will answer quite as well, providing you apply a fly wheel to the cylinder shaft to render the motion equable. To get the best effects from the phonograph the cylinder must be turned with great regularity. 2. Has any improvements been made on the phonograph since you published the above direction July 30, 1878, and if so, what is it? A. No essential changes. You might with advantage substitute a piece of steel watch spring for the wooden spring carrying the needle, and you might put a damping spring against the front of the diaphragm with a piece of rubber or felt under it. These changes will improve the articulation somewhat.

(16) J. A. S. asks how to vulcanize rubber to iron. A. In vulcanizing rubber in contact with iron so that the vulcanized rubber and metal will cohere it is customary to coat the iron all over with a melted mixture of equal parts of gutta percha, asphaltum and gutta percha. Soft rubber containing six per cent of sulphur when firmly pressed into contact with this coating and then vulcanized by steam heat adheres very strongly to the metal after cooling.

(17) G. W. T. asks: Will you, for the benefit of several readers in this city, please give your opinion of gasoline in the household as used in the so-called gas stoves? A. Experience has shown that it is not safe to use gasoline in the house, for gas stoves or otherwise, under any conditions.

(18) C. A. asks: 1. Can you tell me the process of etching on glass by fluorine? A. Heat the glass and coat it with an even film of beeswax or paraffine. Through this to the surface of the glass etch the characters or design with a sharp point or graver. Put into a shallow lead tray a quantity of fluoride of calcium (fluor-spar) in fine powder, add it into a thin paste with strong oil of vitriol and set the tray on a warm sand bath. Place the glass tightly over the tray so that the hydrofluoric acid gases may come into contact with the prepared surface. In ten minutes the parts of the glass not covered with wax or paraffine will be properly etched. The etched lines will be translucent—if it is desired to make the etching opaque white, the plate should be wet before exposing it. A little warm water will remove the wax or paraffine. 2. Can the materials be procured in New York? A. Yes, see our advertising columns for dealers in chemicals.

(19) J. B. E. asks: What is the cost of graphite and where obtainable? A. Prices seven to fourteen cents a pound. See our advertising columns for addresses of dealers. Also Hints to Correspondents.

(20) C. F. writes: 1. On a vehicle of three wheels, weighing from 1,300 to 1,400 lb., with two cylinders 3 inches bore by 4 inches stroke, wheels to be 4 feet high, with engines connected to cranks in back axle, what size boiler is required, thickness of iron, etc.? A. The boiler should be a vertical coil tube boiler, having about 70 square feet of heating surface. 2. Is there any way to make a piece of wood more durable than ordinary lumber for chisel handles, etc.? A. Yes, by impregnating the timber with some of the chemical preparations used for preserving timber. 3. Lime in the Scientific American a description of a canal canoe, in vol. xliii., No. 7. What we wish to know is how long, wide, and deep it should be to hold two persons of 150 lb. each? A. About 9 or 10 feet long by 3 feet wide by 16 inches or 18 inches deep to be safe. 4. What for gum used to be made by dropping it only four inches. Please describe how it was done. A. Lead shot are made by dropping the melted lead through a series of perforations from a height into a bath of water.

(21) F. P. asks: 1. Will adding clay to quicklime increase it? If so, will I use the raw clay or must it be calcined, and how much is to be used? A. The addition of any considerable quantity of raw clay to lime mortar does not improve it materially. A certain quantity of fine siliceous clay, when ground with lime and strongly calcined, makes hydraulic cement. See Gillmore's "Concrete and Mortars." 2. How can I make a good whitewash for outdoor wood work? A. [illegible]

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PROCEEDINGS

OF THE

PHYSICAL SOCIETY OF LONDON.

From December 1919 *to August* 1920.

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MDCCCCXX.

X. *On Recording and Reproducing Sounds by Means of Light.* By A. O. Rankine, *D.Sc., Professor of Physics in the Imperial College of Science and Technology.*

Received November 14, 1919.

(1) *Outline of Experiments.*

In a recent communication to the Physical Society, I have described a method of transmitting speech by light.* In the discussion following the reading of the Paper it was remarked that the method could be adapted to recording sounds photographically, and afterwards reproducing them. Experiments made since then have shown that this is the case, and the results are interesting in several respects.

It has been customary hitherto to record sounds by transverse vibrations, such as, for example, the trace made by a vibrating spot of light on a moving photographic film. The record thus obtained does not lend itself readily to reproduction; but if, instead, sounds can be recorded photographically by means of changes of *intensity* of a beam of light, reproduction becomes quite easy. This process is not new, having been used in 1900 by Rühmer† in connection with experiments on the electric arc. It was developed by him as a means of testing the conditions under which the greatest variations of light intensity could be brought about by the action of microphonic currents superimposed on the current passing through the arc. He finally succeeded both in recording sounds by this means and in reproducing them; but he points out that the method requires laborious manipulation, owing, mainly, to the difficulty of keeping the arc in the sensitive condition. The photophone transmitter described in my previous Paper avoids this difficulty entirely, and enables photographic records of sounds to be obtained with great ease and precision. This is evident from the fact that the examples shown in Fig. 2 are the results of first attempts, and involved no very careful preparation. Probably they can be improved, but they are already sufficiently good to give accurate reproduction of the corresponding sounds.

* "Proc." Physical Soc., Vol. XXXI., p. 242.
† Ernst Rühmer, "Wireless Telephony," 1907.

(2) *Production of the Records.*

It is unnecessary to describe again the photophone transmitter. The light from a 500 c.p. Pointolite lamp was passed through the transmitter, and the emergent fluctuating beam, instead of being projected to a distance, was concentrated upon a narrow horizontal slit, S (Fig. 1), by means of the lens L_1. A second lens, L_2, was used to focus an image of the slit upon a band of kinematograph film, which could be moved in a vertical direction. The film was contained in a special camera, actuated by clockwork, which enabled about 2 metres of film to be run at nearly constant speed. In order to obtain as much detail as possible, the image of the slit on the film was made very narrow—between 0·1 mm. and 0·2 mm.—and

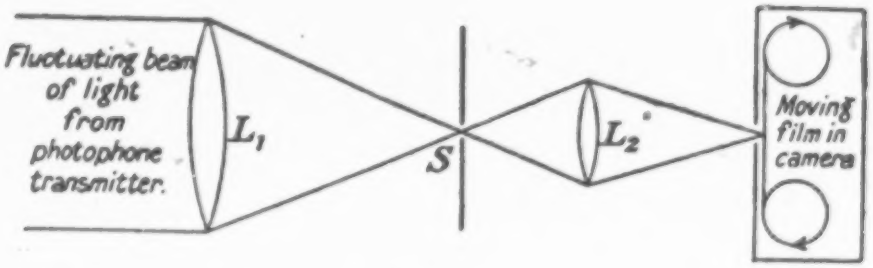
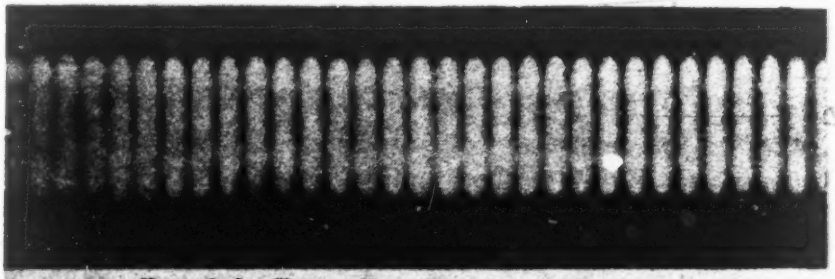


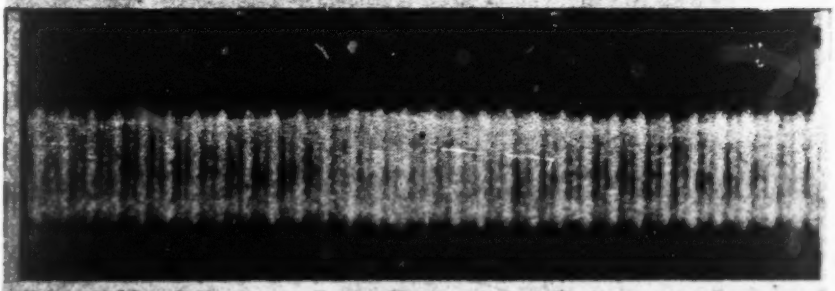
FIG. 1.

the film run at considerable speed—about 170 cm. per second. In these circumstances the film was, perhaps, rather underexposed, and improvements could, no doubt, be obtained by using a source of greater intrinsic brilliancy.

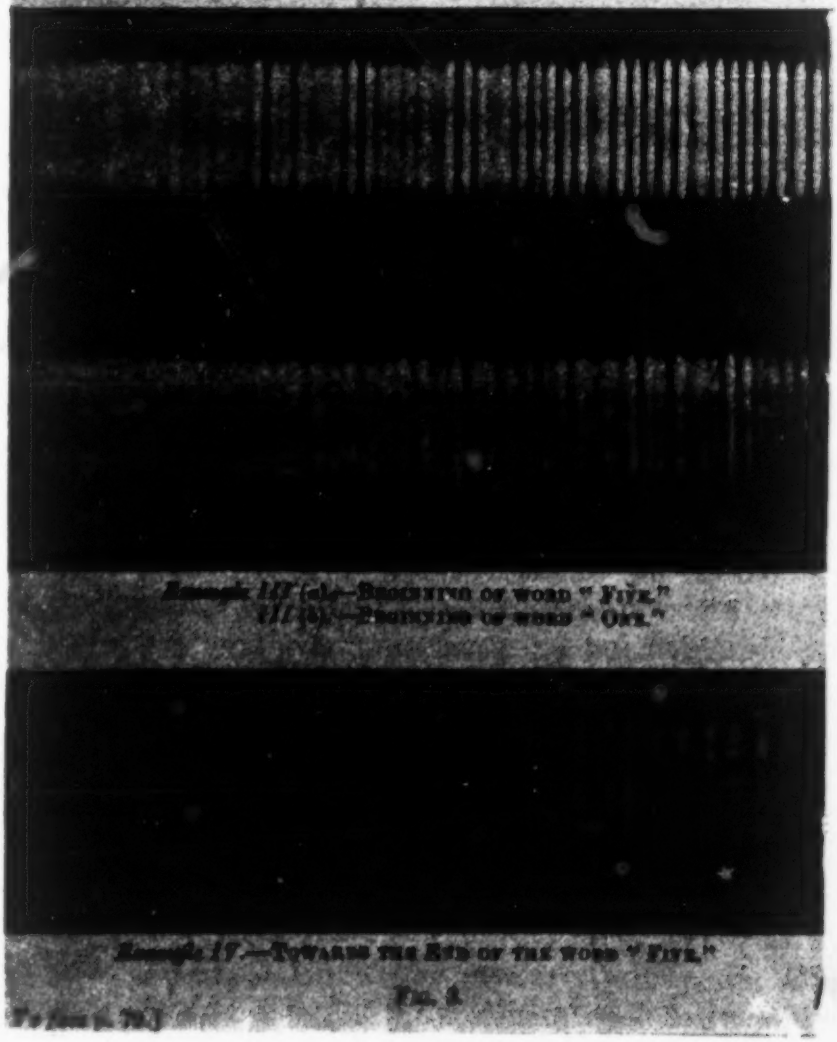
Examples of the results obtained are shown in Fig. 2, which represents positive prints taken from portions of the films. Example I. is the record of the vibrations of a tuning fork (frequency 512 per second) bowed and then held near the receiving trumpet of the transmitter. As might have been expected, the fundamental frequency only is indicated. Example II. was produced by an open organ pipe of fundamental frequency, 520 per second. Here the effect of the first overtone (frequency 1,040 per second) is seen superimposed on the fundamental. Examples III.*a* and III.*b* represent respectively the beginnings of the words "five" and "one." Space is not sufficient to show the complete words, each of which, although only a monosyllable, has, on the scale shown, a visible record about 40 cm. long. Example IV. is the record of that part of the word "five" where the "*i*" sound changes to the "*v*" sound. Progression is from left to right, and the change of



Example I.—Tuning Fork Frequency 512 per sec.



Example II.—Open Organ Pipe. Fundamental Frequency 520 per sec.



Example III (*a*).—Beginning of word "Five."
III (*b*).—Beginning of word "Oft."

Example IV.—Towards the End of the word "Five."

Fig. 8.

To face p. 72.]

character is shown fairly well. Sufficient photographs have been taken to show that in different records of the same word the general features are repeated, although the identity of detail is not, perhaps, as complete as might have been expected. It appears probable that even the same person, speaking the same word several times, does not actually repeat the vibrations identically. At any rate, it is totally unnecessary for him to do so, for, as will be seen later, speech communication requires only the existence of the principle features of the vibrations.

(3) *Reproduction of Sounds from the Records.*

In order to reproduce the sounds from the films, all that is necessary is to focus the light from a narrow source upon the film and allow the light which penetrates the film to fall upon a selenium cell connected with a battery and telephone receiver. A convenient arrangement is shown in Fig. 3, where the light from the arc illuminates the horizontal slit S, and the lens L

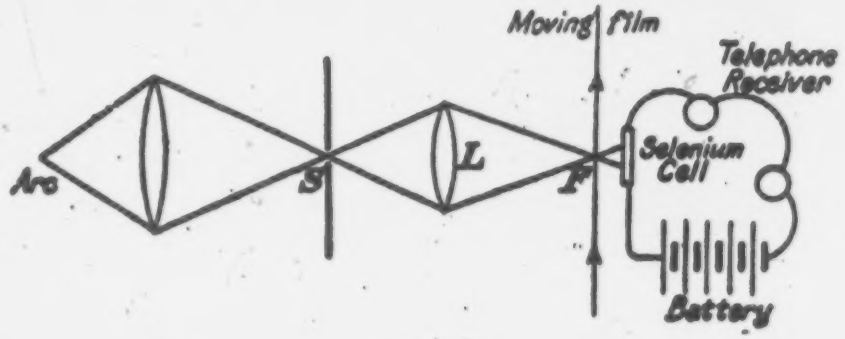


FIG. 3.

produces an image of the slit on the film at F. The light penetrating the film fluctuates when the latter is moved rapidly, and sounds are heard in the telephone receiver. The reproduction thus obtained is good, and there is a quite remarkable amount of latitude in adjustment without noticeable deterioration of articulation. In the first place, it may be noticed that there is no need to use in reproduction a positive of the original negative film; the negative itself serves quite well. This means that the phase of the vibrations may be reversed throughout without any effect on the sounds heard. Secondly, it is apparently quite unnecessary to take any special care in the development of the film with a view to securing that the opacity is proportional to the intensity of the incident light. It is sufficient that the main frequency charac-

teristics should be represented by alternations of opacity. Further, it is not essential that the speed of the film during reproduction should be precisely the same as that during recording, in so far as the articulation of a word is concerned. The general pitch, of course, changes with speed; but it is possible to recognise the same word even if its record is run at a wide range of speeds. But the most remarkable fact of all is the small effect produced by alterations of width of the illuminating slit. The width of the slit image on the film during recording was less than 0·2 mm., yet in reproduction one can increase its width to considerably over 1 mm. without any marked effect on articulation. This means that the ear can be very easily deceived, and that only a rough approximation to the original vibrations is necessary in the reproduction of sounds required in ordinary listening. The practical effect is that there is no need for the film to be run at so great a speed as that used in these experiments. Probably a speed of 40 cm. per second would be quite sufficient with a slit image 0·2 mm. wide both in recording and reproduction. From the point of view of the visual examination of the records, higher speeds are, of course, preferable.

(4) *Significance of the Records.*

An interesting feature of the records is that they provide pictures of sound waves much more exact than is possible by representing them in the usual way as transverse vibrations. They give, in fact, a fair representation of the condition of *longitudinal* displacements which travel through the air. The changes of photographic density on the film record correspond to the changes of density in the air, and the record of any sound may thus be regarded as an instantaneous picture of the succession of compressions and rarefactions in the associated sound wave.

Different words have records which differ greatly in appearance. By increasing further the speed of the recording film in relation to the width of the slit, it is probable that these differences can be still further accentuated, so as to show clearly the differences between such sounds as, for example, "th" and "z." In this respect they may be useful to students of phonetics. It might even be possible for persons to overcome the difficulty of saying "th" by learning to create the pressure changes indicated on the "th" record.

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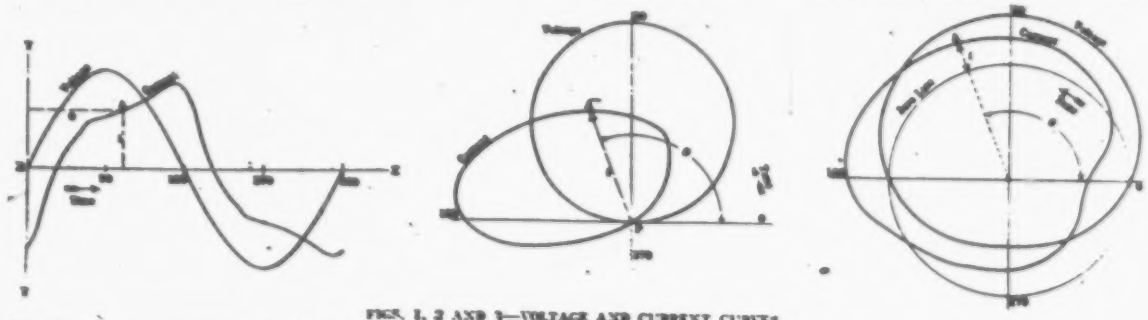
Polar and Circular Oscillograms and Their Practical Application

L. W. Chubb

FOREWORD—In a recent article[*] a new harmonic analyzer was described which works mechanically from a polar or circular curve of the wave to be analyzed. The present article describes the apparatus and method used in taking polar oscillograms, brings out some additional uses of the polar curves and shows some short cuts and new methods of calculation.

VARIATIONS and fluctuations in any quantity or mathematical function are conveniently expressed graphically with curves and waves. Such curves may be used to give only a mental picture of a certain variable function or may be used for more exact measurements and calculations. When quantitative results are to be expressed it is necessary to refer the curve to certain coördinate axes or reference points. To do this several systems of coördinates have been used but only two, the rectangular or Cartesian, and circular or polar systems are in common use. In the former plane curves are referred to two perpendicular lines or axes, and in the latter the points of the curves are located by their distance from a point called the pole and the angle subtended between a reference line through the pole and the radius vector or line joining the pole and the point in question.



FIGS. 1, 2 AND 3—VOLTAGE AND CURRENT CURVES

Fig. 1—As referred to rectangular axes. Fig. 2—As referred to a polar axis. Fig. 3—As referred to a circular zero line.

Oscillograms or photographic records of electrical waves are generally recorded on rectangular coördinates on a moving photographic plate or a film wrapped around a revolving cylindrical drum. Two distinct types of curves are recorded by the oscillograph, those which are periodic and those which show transient phenomena. Transient curves should properly be expressed in rectangular form but periodic waves can profitably be recorded in circular or polar form.

Figs. 1, 2 and 3 show three graphical methods of expressing the periodic exciting current and voltage of a transformer. Fig. 1 shows the common form of curve in which the cycle is referred to two perpendicular lines. The abscissa or horizontal scale shows time or electrical degrees and the ordinate or vertical scale shows the variations of current and voltage above and below the zero value. Fig. 2 shows the polar curves of the same functions, and any point such as A on the current curve is located by the angle Θ between the horizontal axis and the radius vector i and the distance i (amperes) from the pole P. Fig 3 shows another polar curve or circular curve in which the same point A is located by the angle Θ and the radial distance from the zero line or reference circle. Figs. 2 and 3 are both polar curves, the only difference being that in Fig. 3 the radius vector is a constant (radius of the zero circle) plus the value of current or voltage, while in Fig. 2 these functions are measured directly from the pole in the plus or minus direction on the radius vector. With the true polar curve, Fig. 2, the two lobes or half cycles of the curves are coincident (when only odd harmonic components are present) as the negative values are measured in a direction opposite to the angular reference line or radius vector, and the sequence of values in the two half cycles of the curves are the same except for sign.

Oscillograms of periodic curves can best be taken in the form shown in Fig. 3, but in some cases the true polar form is better as will be shown later. To record photographically the motions of the spot of light of the oscillograph in polar or circular form a sensitive disc film is made to revolve about its center and the spot of light made to vibrate radially on the film. Fig. 4 shows the film holder used in taking circular oscillograms. It consists of a light tight casing in which the film is revolved at synchronous speed on the shaft of a small motor. The motor is mounted on the back of the apparatus and its shaft extends through a felt bushed hole to the inside of the casing. A flywheel

[*]See "The Analysis of Periodic Waves" in the JOURNAL for February, 1914.

of sheet steel 10 inches in diameter is mounted on the shaft and the photographic film of the same diameter is secured to the shaft directly in front of the flywheel. Fig. 5 shows an exploded view of the film holder with the parts indicated. The front of the casing is secured with wing-nuts and can easily be removed in the dark room or in a bag to load or withdraw the films. A radial slot *S*, about four inches long, is arranged with a sliding shutter. This shutter is provided with a wedge shaped opening so that as it slides past the slot the exposure at the different distances from the center will be proportional to the radius and equalize the impression on the film at all points. The extension *D* at the bottom of the apparatus is pushed in or pulled out to operate or slide the shutter. On the face of the casing is a brass plate *P* which fits on the film holder slots of the oscillograph, and when the apparatus is in place, the spot of light from the oscillograph element vibrates radially in and out from a zero position near the center of the slot. Since the film is run at synchronous speed the shutter can be left open for several revolutions of the film and each part of the film will be exposed several times instead of just once, as is the case with the usual oscillographic apparatus.

FIG. 4—FILM HOLDER FOR USE IN TAKING CIRCULAR OSCILLOGRAMS

FIG. 5—EXPLODED VIEW OF FILM HOLDER
A—Flywheel. *B*—Film.

Fig. 6 shows the apparatus attached to the oscillograph, and also the apparatus used to tell when the film is running at synchronous speed. The natural drive for the film would be a synchronous motor, but such a motor is not practical because often sufficient alternating current cannot be taken from the circuit without disturbing the conditions of test. For this reason the film motor is a series commutator motor which can be run on the same circuit, another alternating current circuit or on a direct-current circuit. Synchronous speed is indicated by observing a vibrating reed *R* through a stroboscopic slot in a small cylindrical extension on the shaft of the motor. The reed is very small and is arranged with a movable fret *F* so that its natural period of vibration can be adjusted to agree with the frequency of the circuit and made to vibrate electromagnetically with a very feeble current. The speed of the motor is varied until the vibrating reed observed through the stroboscopic slot is apparently standing still. When synchronous speed is thus indicated the shutter is operated by pressing the lever *L*. Usually two exposures are made, one to record the periodic waves and the other, with the oscillographic switches open, to record the zero lines or reference circles.

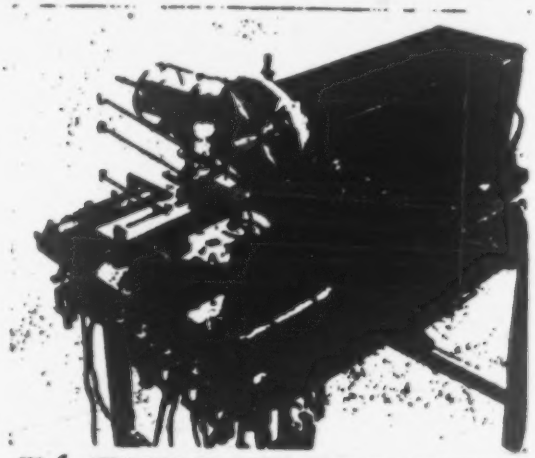


FIG. 6—APPARATUS FOR TAKING CIRCULAR OSCILLOGRAMS

Until an engineer is used to the polar pictures of electrical waves, they seem somewhat confusing and do not give at a glance the clear conception that the rectangular pictures do. However, for general usefulness and accuracy they have proved to be much more valuable than the former type as a single cycle is several times as long and this extension of the time scale and the geometric form of the curve allow more accurate sub-division and more simple and accurate calculations of phase angles, harmonic analysis, square root of mean square values, power in watts, power-factor, wave shape distortion, distortion factor, etc.

The *method* of using the circular oscillograms for harmonic analysis has already been covered in the former article. The other constants and ratios mentioned above can be calculated directly from the circular oscillogram or indirectly from the results of the

THE PHYSICAL REVIEW

A JOURNAL OF EXPERIMENTAL AND THEORETICAL PHYSICS

CONDUCTED BY

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VOL. X., SERIES II.

THE PHYSICAL REVIEW

LANCASTER, PA., AND ITHACA, N. Y.

modern physics. For the present at least it is truth, and no other theory of atomic structure need be considered until it has shown itself able to approach it in fertility. I know of no competitor which is as yet even in sight. I am well aware that the facts of organic chemistry seem to demand that the valence electrons be grouped in certain definite equilibrium positions about the periphery of the atom, and that at first sight this demand appears difficult to reconcile with the theory of electronic orbits. As yet, however, there is no necessary clash. Hydrogen and helium present no difficulties, since the former has but one valency, and the latter none. It is to these atoms alone that the unmodified Bohr theory applies, for it treats only the case of a single negative electron rotating about a positive nucleus. That the K radiations of the heavy elements are so accurately predictable from those of hydrogen indicates indeed that close to the nucleus of these elements there lie electrons to which the Bohr theory fairly accurately applies, but the radiations give us no information about the conditions or behaviors of the external electrons which have to do with the phenomena of valency, and we have investigated but little the radiating properties of the atoms which possess but few electrons. A further study of the behavior with respect to X-rays of the elements from lithium, atomic member 3, to magnesium, atomic number 11, may be expected to throw new light on this problem.

It has been objected too that the Bohr theory is not a radiation theory because it gives us no picture of the mechanism of the production of the frequency ν. This is true, and therein lies its strength, just as the strength of the 1st and 2nd laws of thermodynamics lies in the fact that they are true irrespective of a mechanism. The Bohr theory is a theory of atomic structure; it is not a theory of radiation, for it merely states what energy relations must exist when radiation, whatever its mechanism, takes place. As a theory of atomic structure, however, it is thus far a tremendous success. The radiation problem is still the most illusive and the most fascinating problem of modern physics. I hope to discuss it at a later time.

Amplification of the Photoelectric Current by the Audion.[1]

By Jakob Kunz.

THE photoelectric cell is used already as a photometer for many scientific investigations, for instance in stellar photometry, in plant physiology, in researches on phosphorescence, on transmission, absorption, reflexion and radiation of light in various forms. It would find further applications, even for technical purposes, if the photoelectric current were larger. The writer has some time ago constructed a photoelectric relay, where the primary photoelectric current was increased considerably by a second electric field in the cell. However this relay has not been studied and developed sufficiently and it was

[1] Abstract of a paper presented at the Washington meeting of the Physical Society, April 20–21, 1917.

found that the audion, which has already so many important applications, amplifies the photoelectric current to a higher degree than the relay. The arrangement of the apparatus is given in the following figure, where P represents the photoelectric cell, G_1 and G_2 two galvanometers, B_1, B_2, B_3 batteries of 120, 20 and 8 volts; A the audion. The photoelectric cell was illuminated

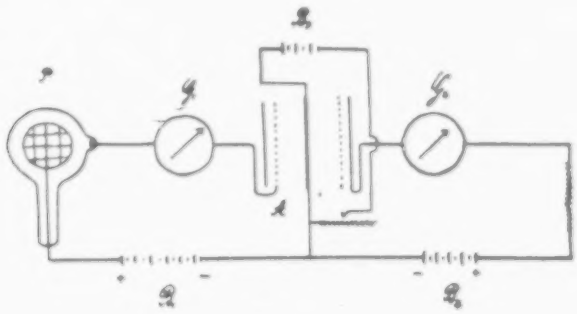


Fig. 1.

by an incandescent lamp of 2 candles at various distances from 30 to 170 cm. from the cell; the battery B_3 supplies the heating current of the filament of the audion. The galvanometer G_1 of the primary circuit was 32 times more sensitive than G_2 of the secondary circuit. The amplification of the photoelectric current by the audion depends largely on the temperature of the incandescent filament; the higher the temperature, the greater the secondary current, as will be seen from the following readings.

34, 5	102
34, 0	130
34	180
33	250
33	500

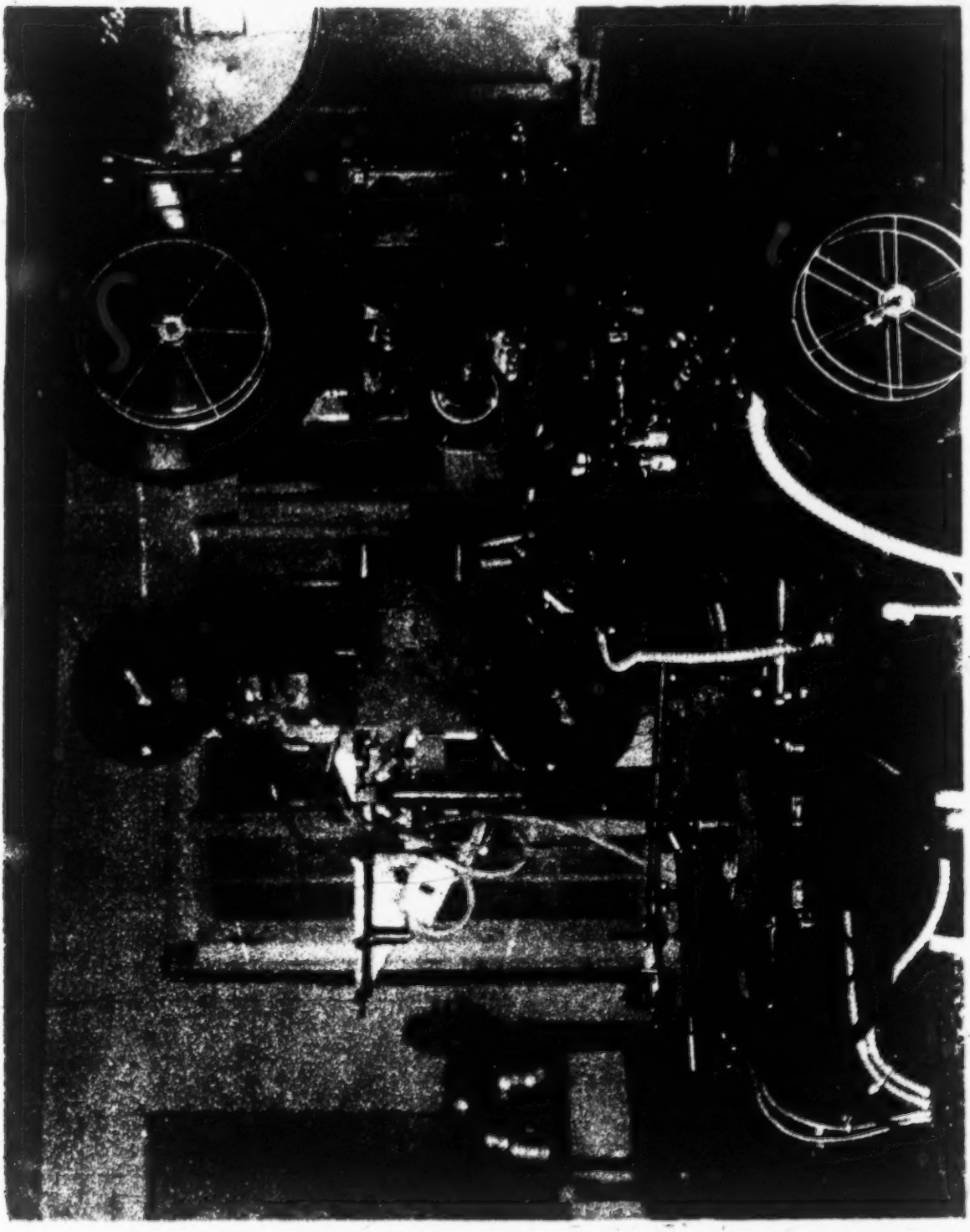
When the deflection of the secondary galvanometer was 500, the temperature of the filament was that of beginning white heat; the secondary deflection is 15 times larger than the primary, or the secondary current is 480 times larger than the primary photoelectric current. And it was easy by raising the temperature to amplify the photoelectric current 1000 times. With higher temperatures the secondary currents become less steady. A small variation of illumination produces a large variation in the secondary deflection. The voltage applied to the photoelectric cell connected with the audion can be raised above the point, where the glow in the cell sets in when independent of the audion.

LABORATORY OF PHYSICS,
UNIVERSITY OF ILLINOIS,
URBANA, ILLINOIS, April, 1917.

DEFENDANTS' EXHIBIT NO. 76.

Defendants' Alleged Infringing Apparatus PS 1, Includ Turntable and Stand.

(Physical Exhibit.)

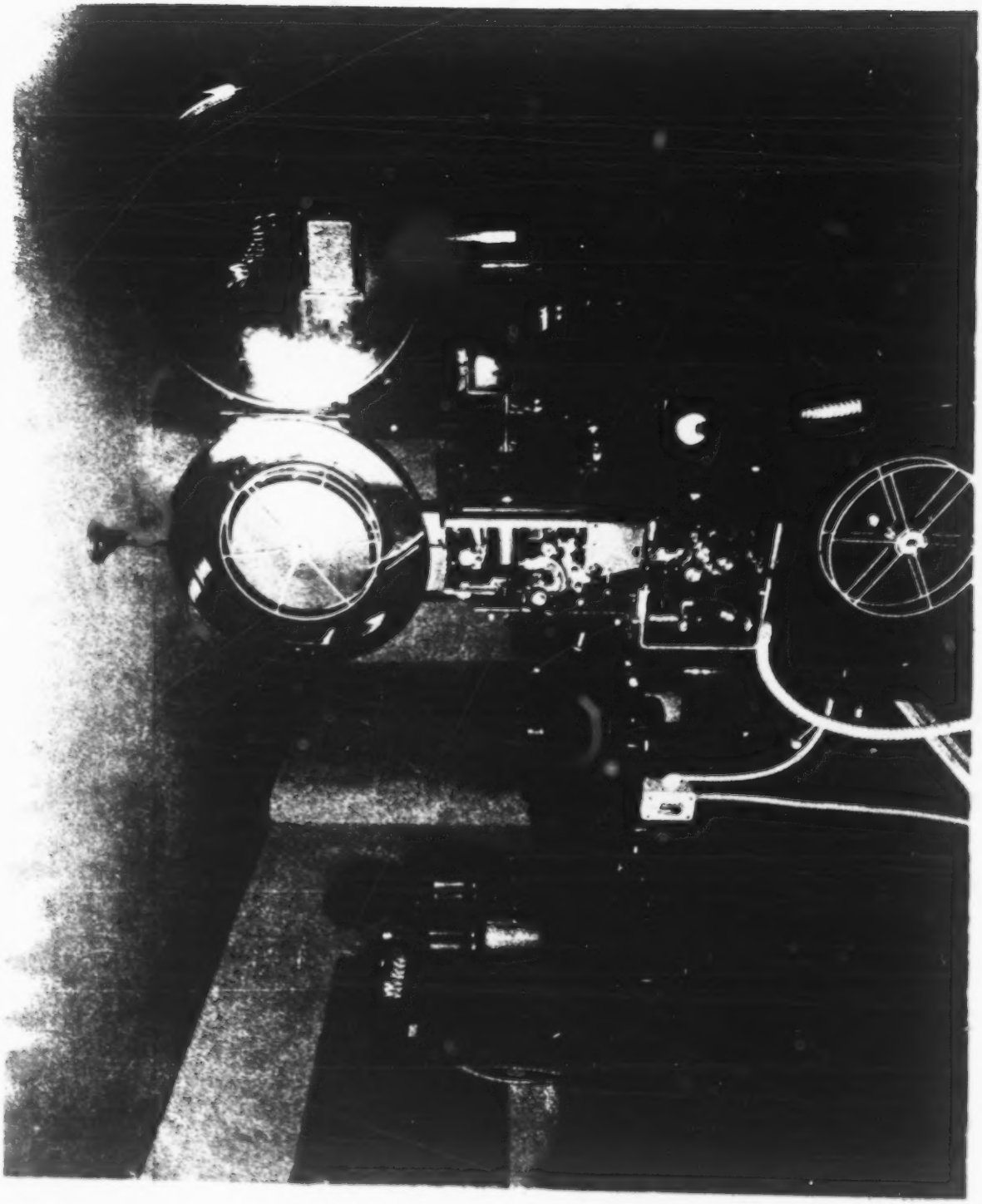


DEFENDANTS' EXHIBIT NO. 77.

Defendants' Alleged Infringing Apparatus PS 16.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 77-A.

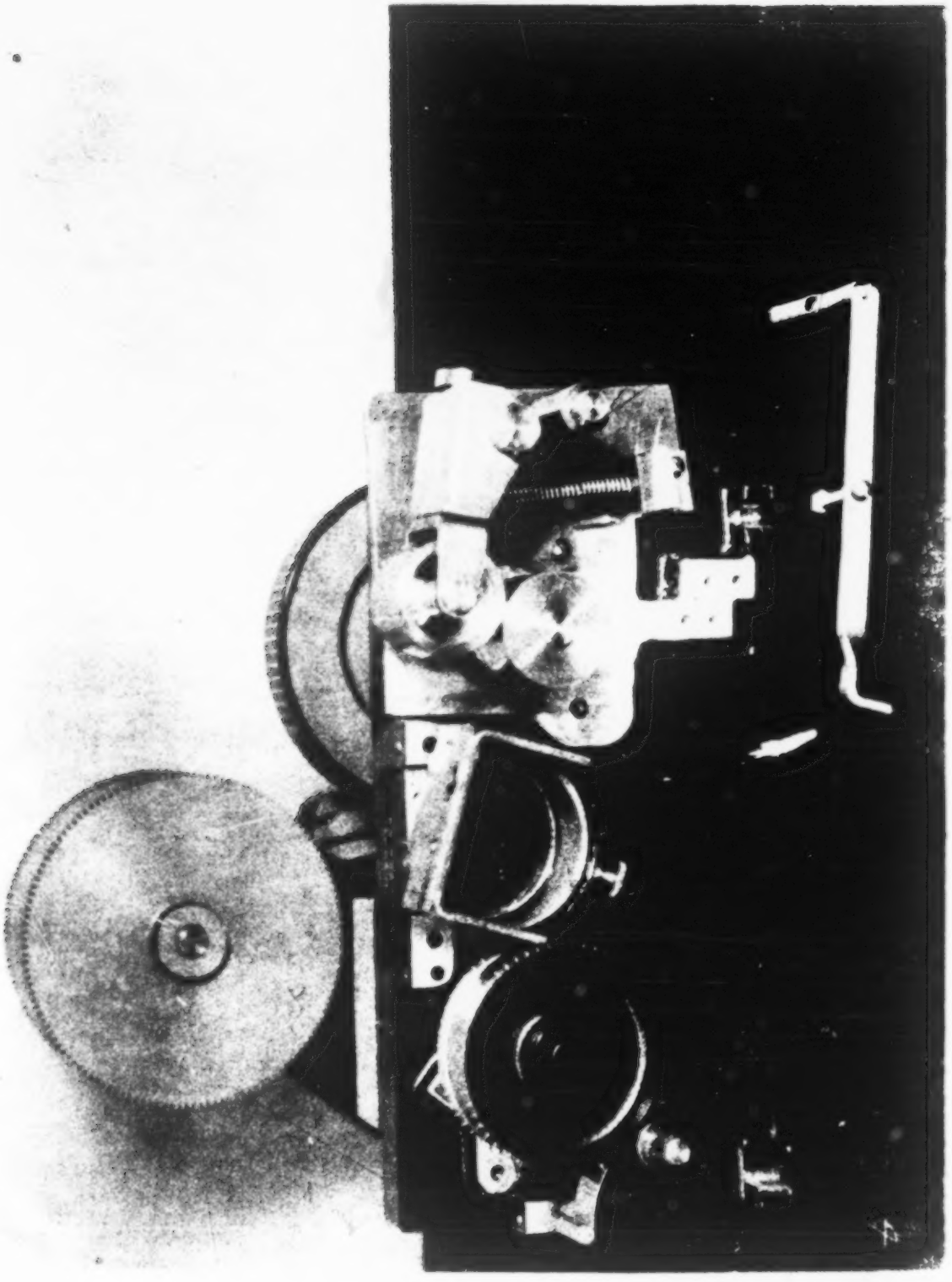


DEFENDANTS' EXHIBIT NO. 78.

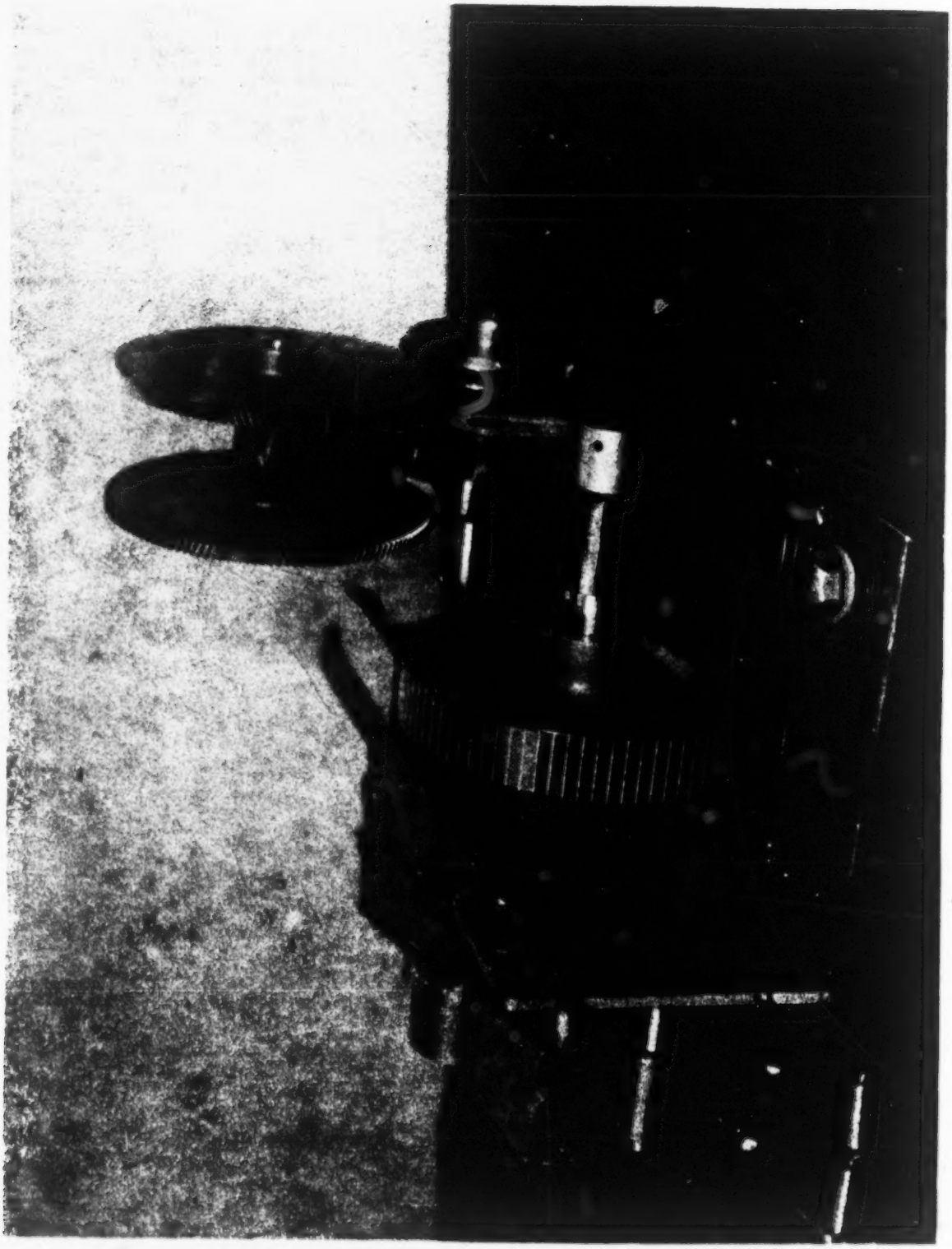
Defendants' Model of Figure 1 of Vogt, Massole and Engl German Patent No. 387,058.

(Physical Exhibit.)

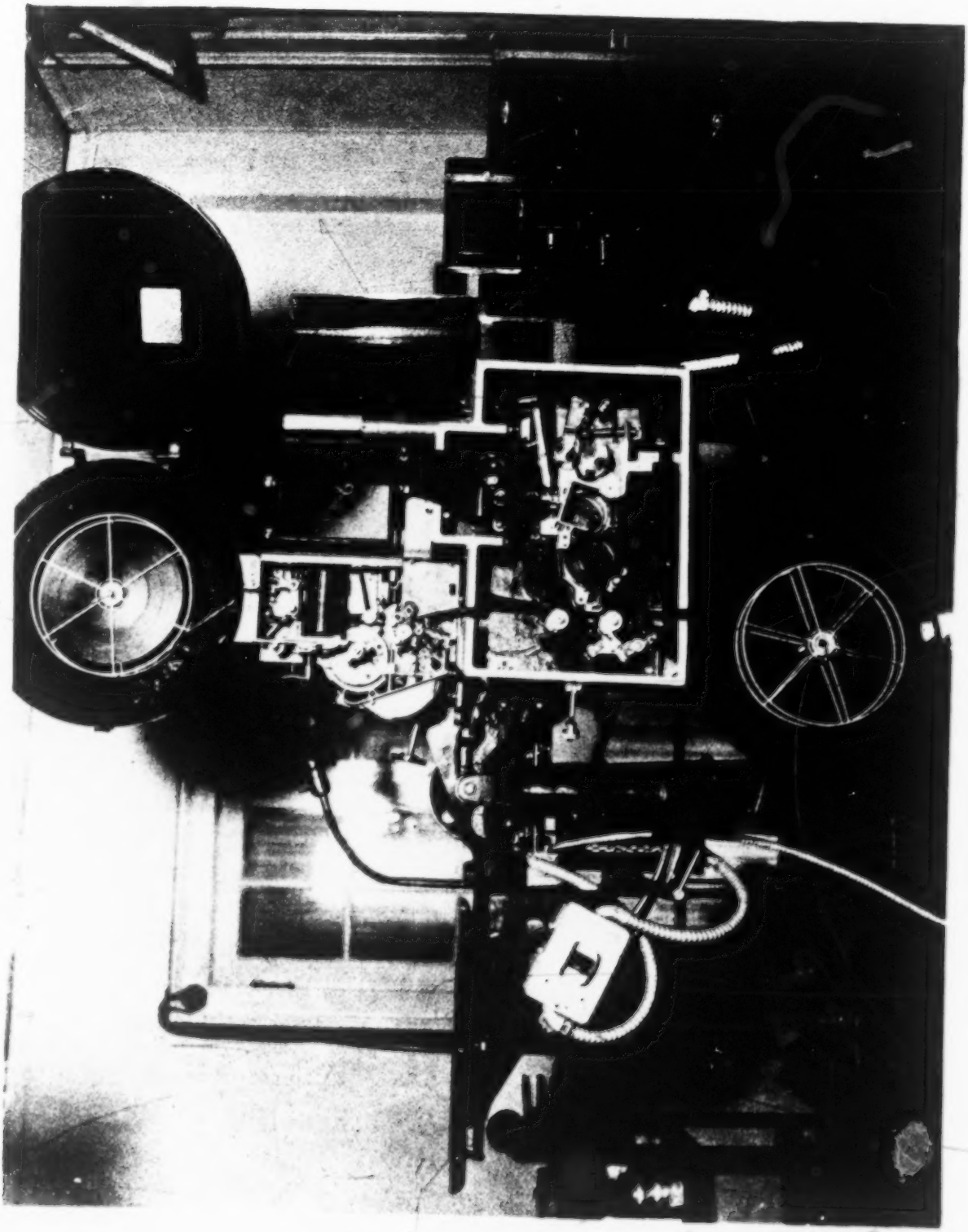
DEFENDANTS' EXHIBIT NO. 78-A.



DEFENDANTS' EXHIBIT NO. 76-B.



DEFENDANTS' EXHIBIT NO. 78-C.



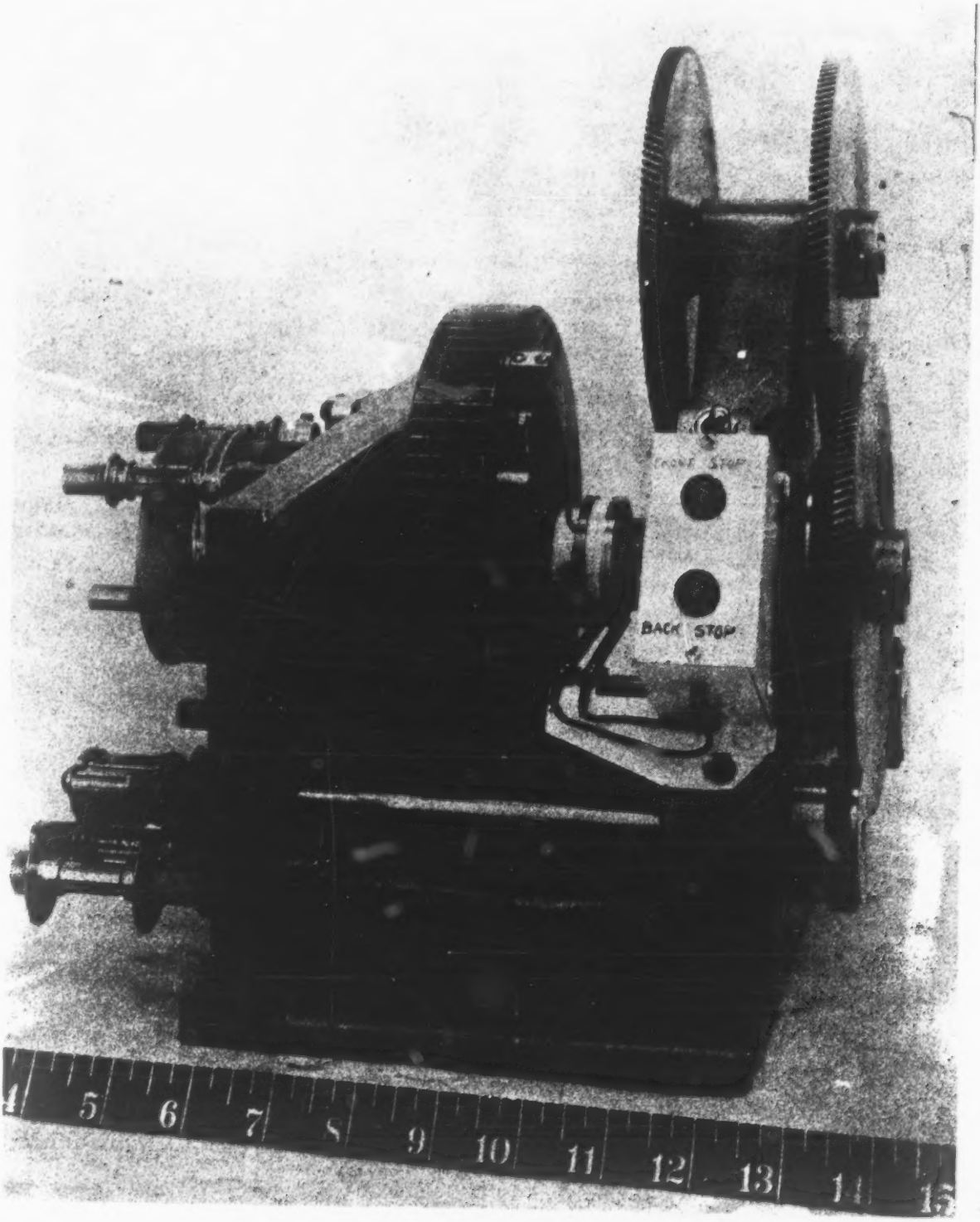
DEFENDANTS' EXHIBIT NO. 79.

Defendants' Model of Figure 5 of Patent in Suit.

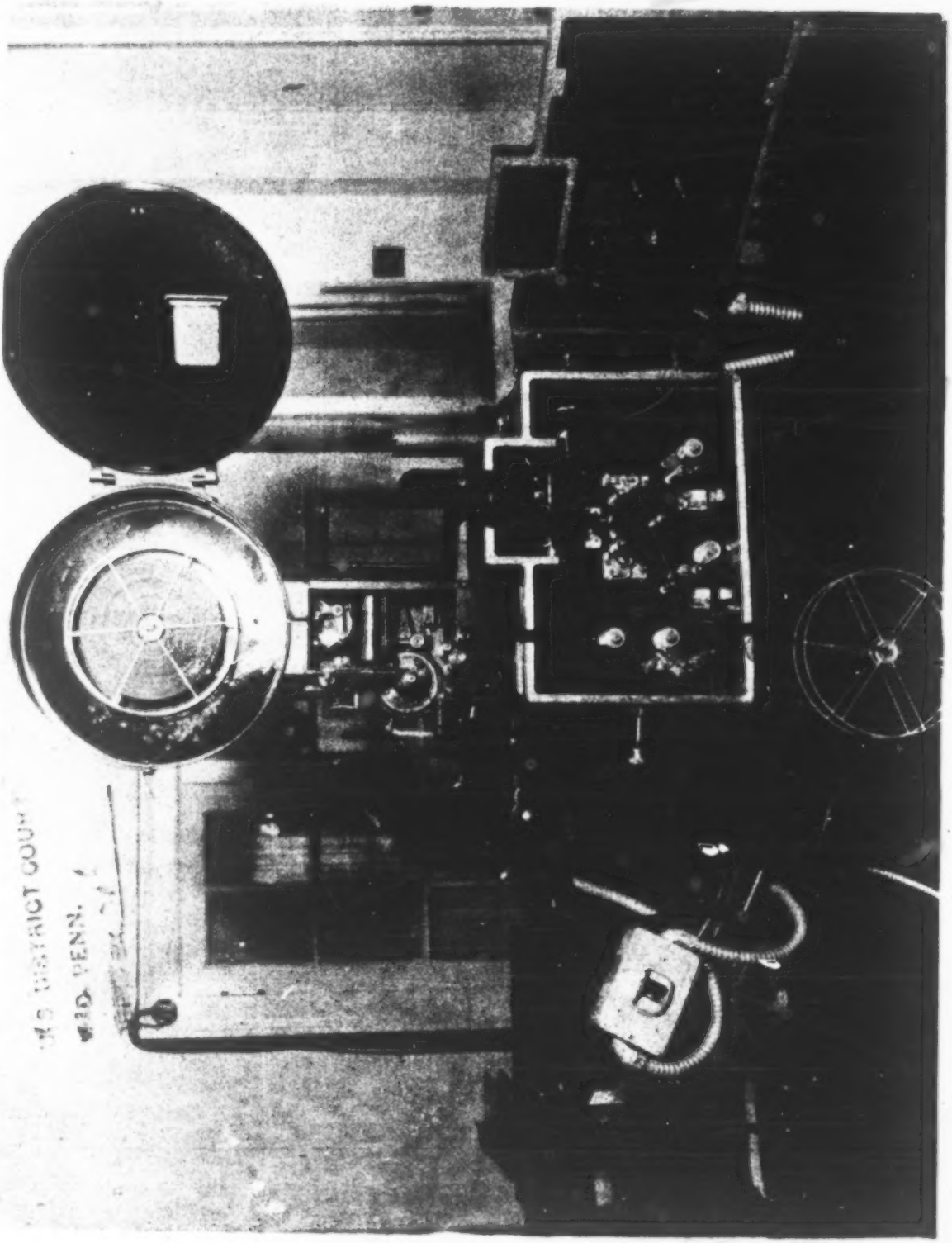
(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 79-A.

DEFENDANTS' EXHIBIT NO. 79-B.



DEFENDANTS' EXHIBIT NO. 79-C.

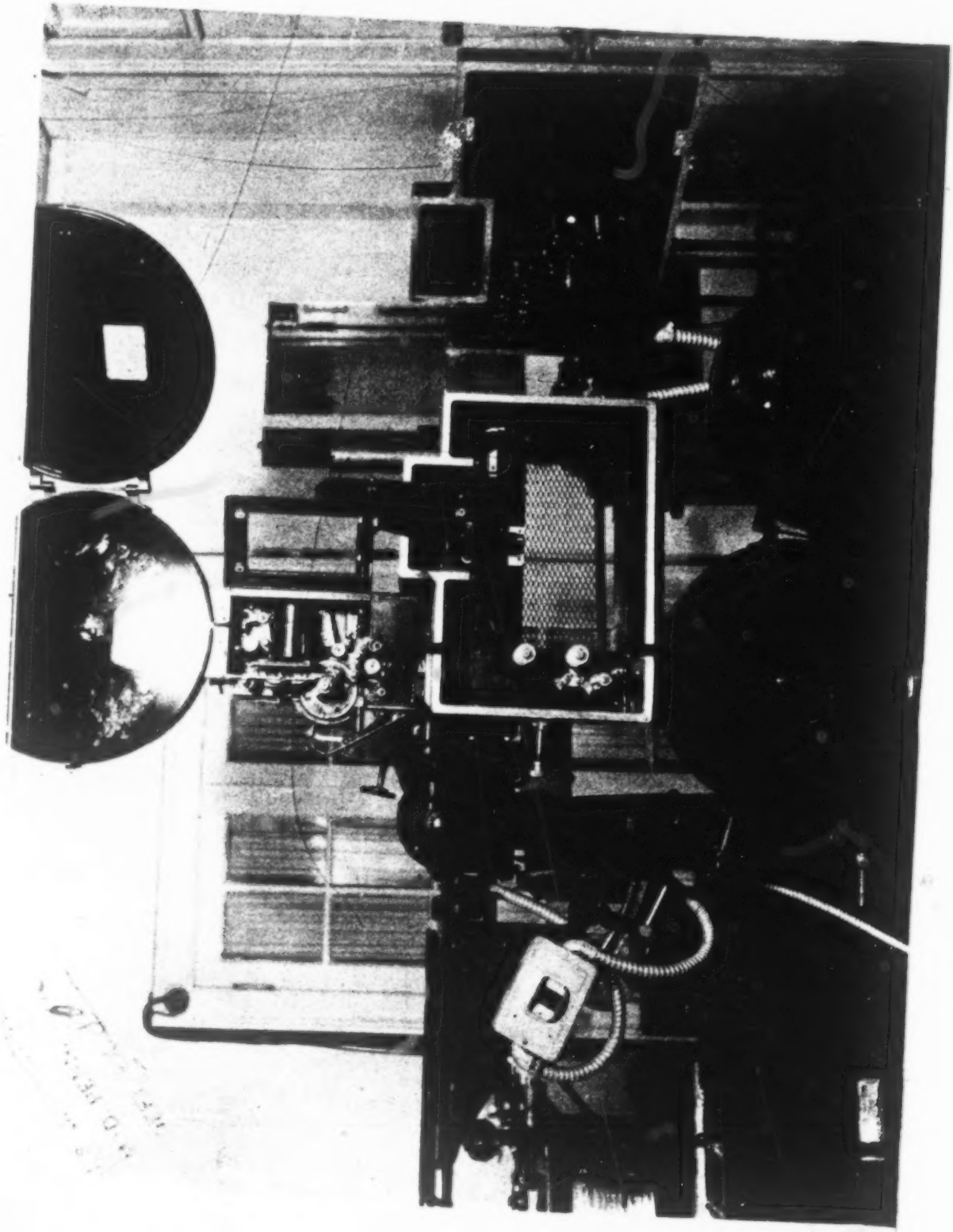


DEFENDANTS' EXHIBIT NO. 80.

Defendants' Machine in Which Models of German 387,058 and Fig. 5 of Patent in Suit Were Demonstrated.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 80-A.



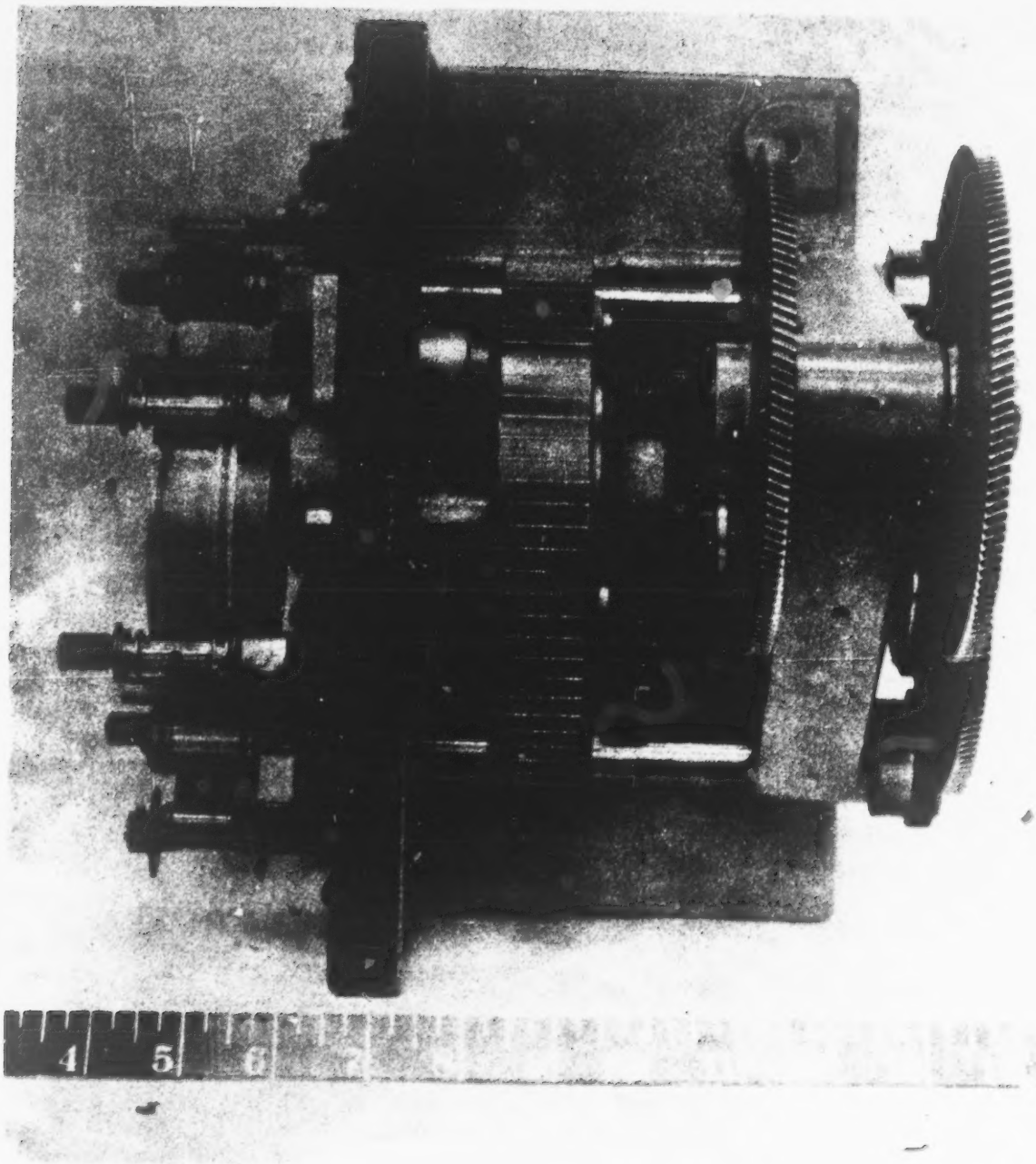
8341

DEFENDANTS' EXHIBIT NO. 81.

Defendants' Model of Amet Drive, as Demonstrated in Place of Spring Drive of Fig. 5 of Patent in Suit.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 81-A.

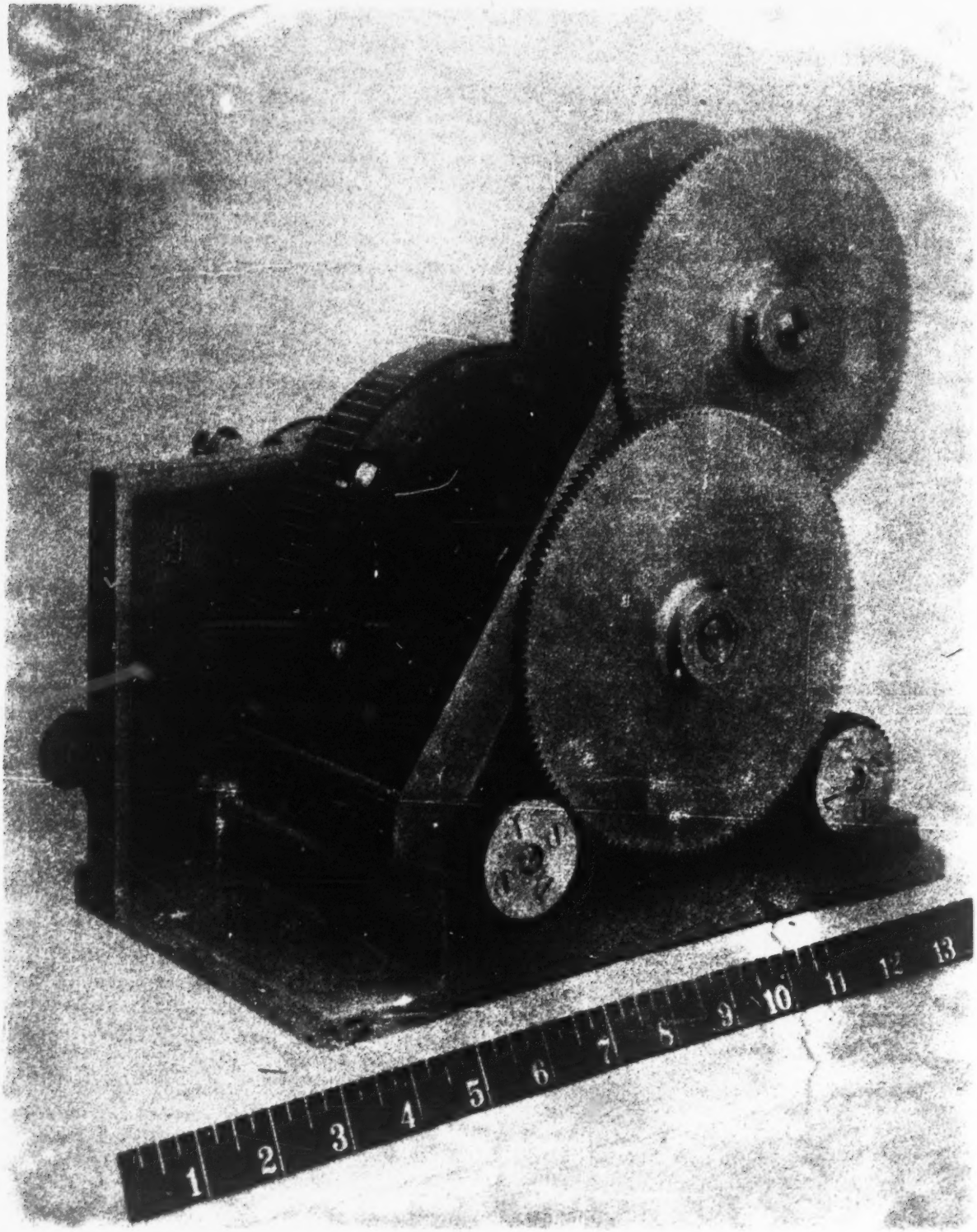


DEFENDANTS' EXHIBIT NO. 82.

Defendants' Model of Spring Drive of Constable Patent No. 1,425,177, as Demonstrated, in Place of Spring Drive of Fig. 5 of Patent in Suit.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 82-A.

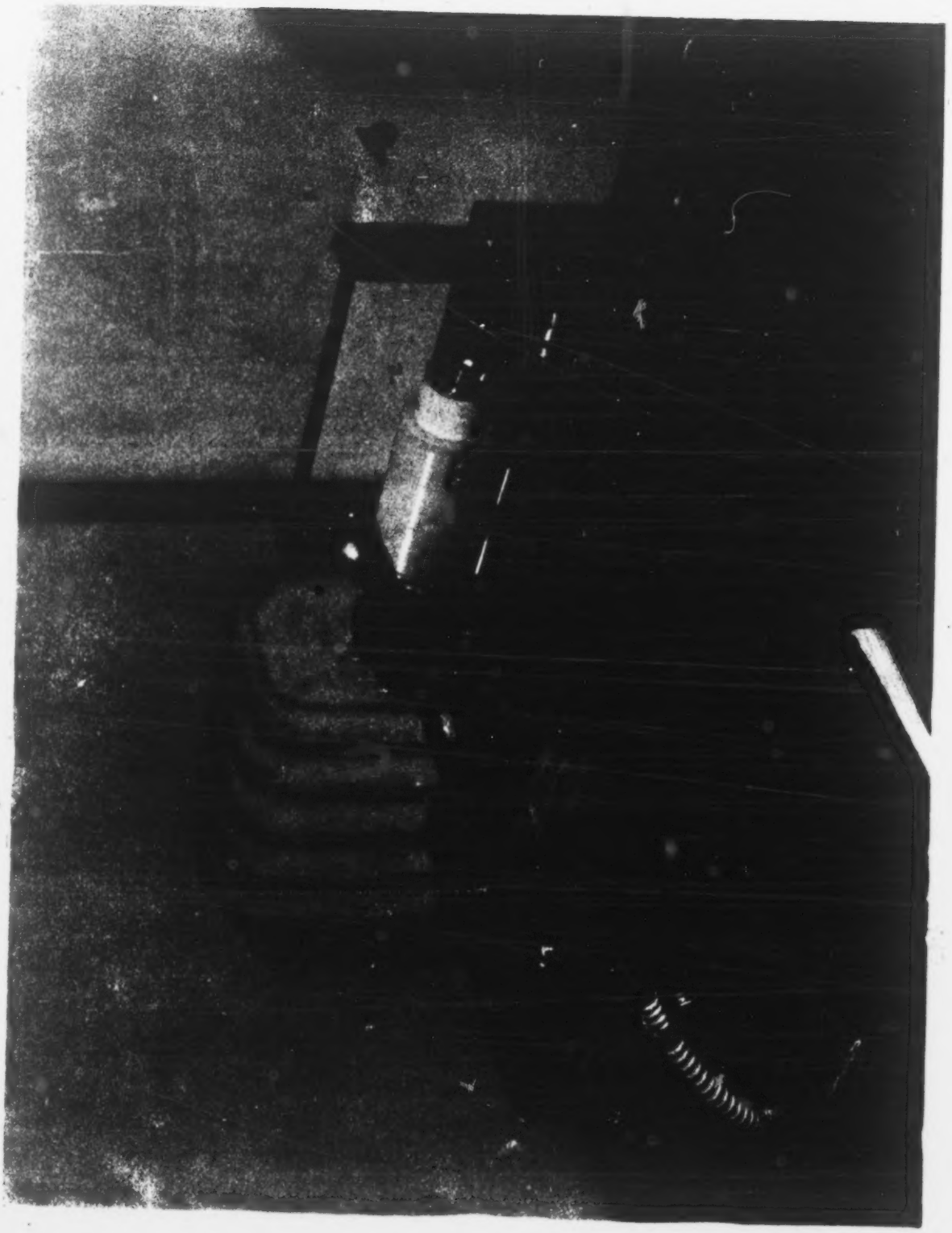


DEFENDANTS' EXHIBIT NO. 83.

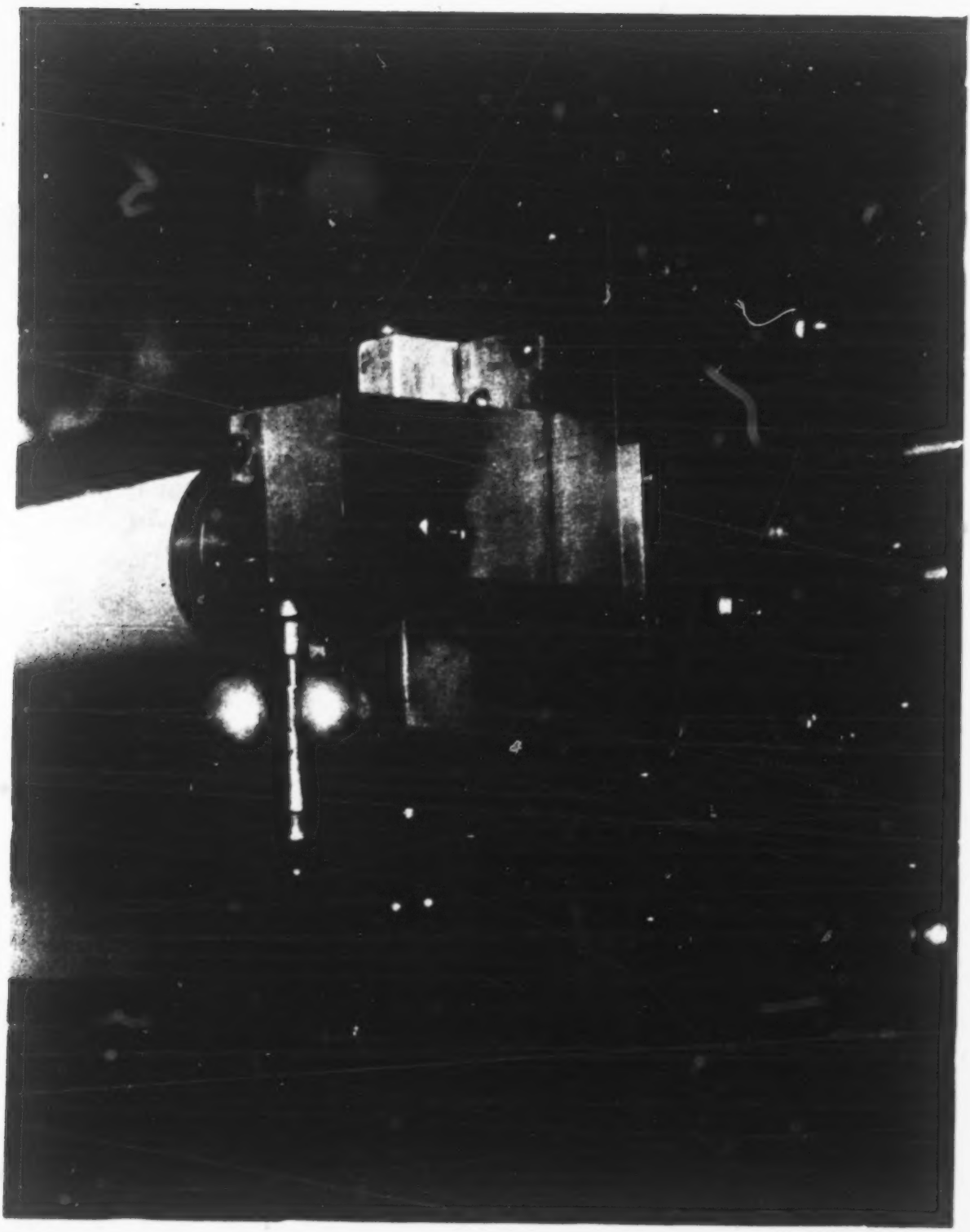
Defendants' Model of Machine of Constable Patent No. 1,425,177.

(Physical Exhibit.)

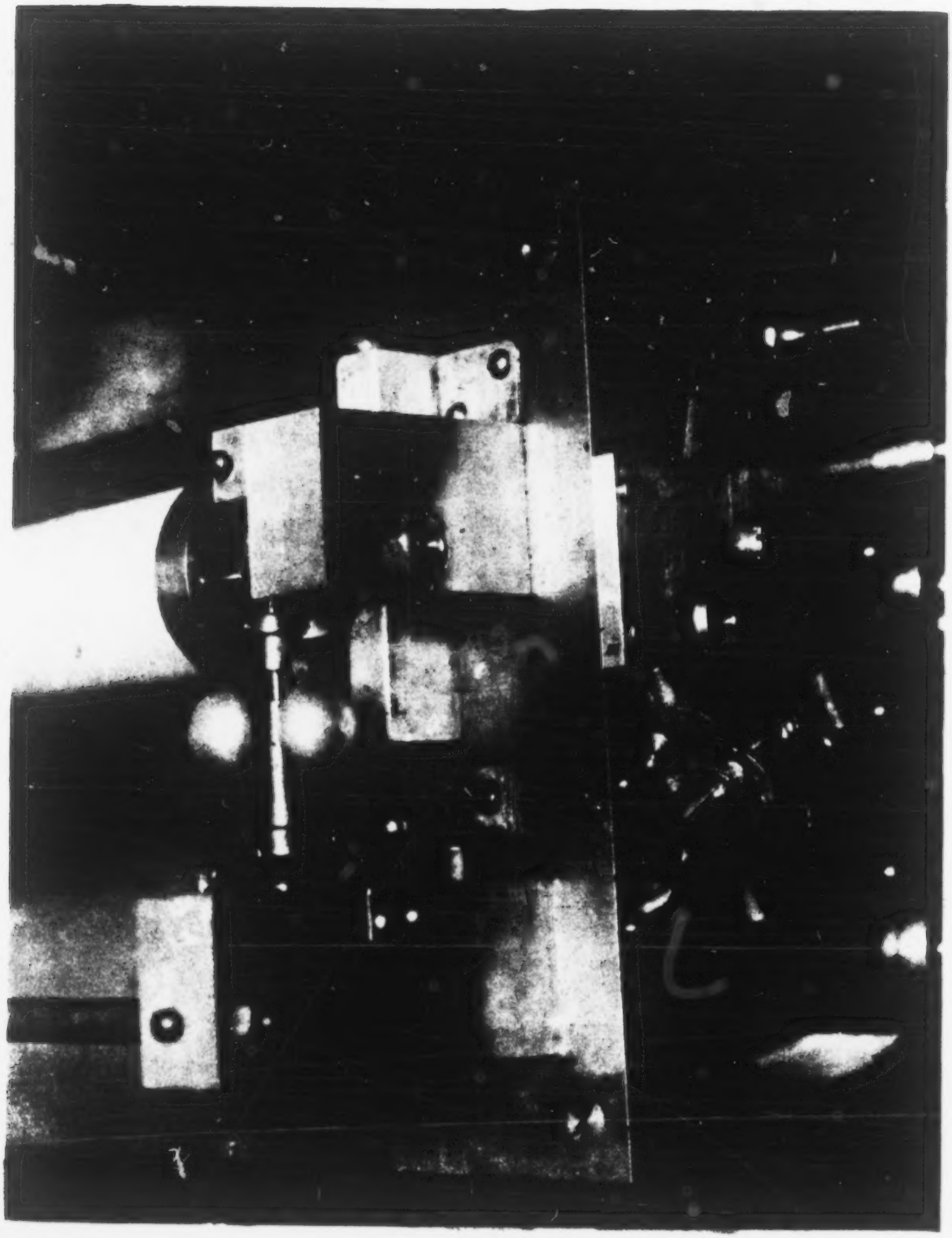
DEFENDANTS' EXHIBIT NO. 83-A.



DEFENDANTS' EXHIBIT NO. 83-B.



DEFENDANTS' EXHIBIT NO. 83-C.



DEFENDANTS' EXHIBIT NO. 84.

Defendants' Model Referred to as Edison Skeleton Model.

(Physical Exhibit.)

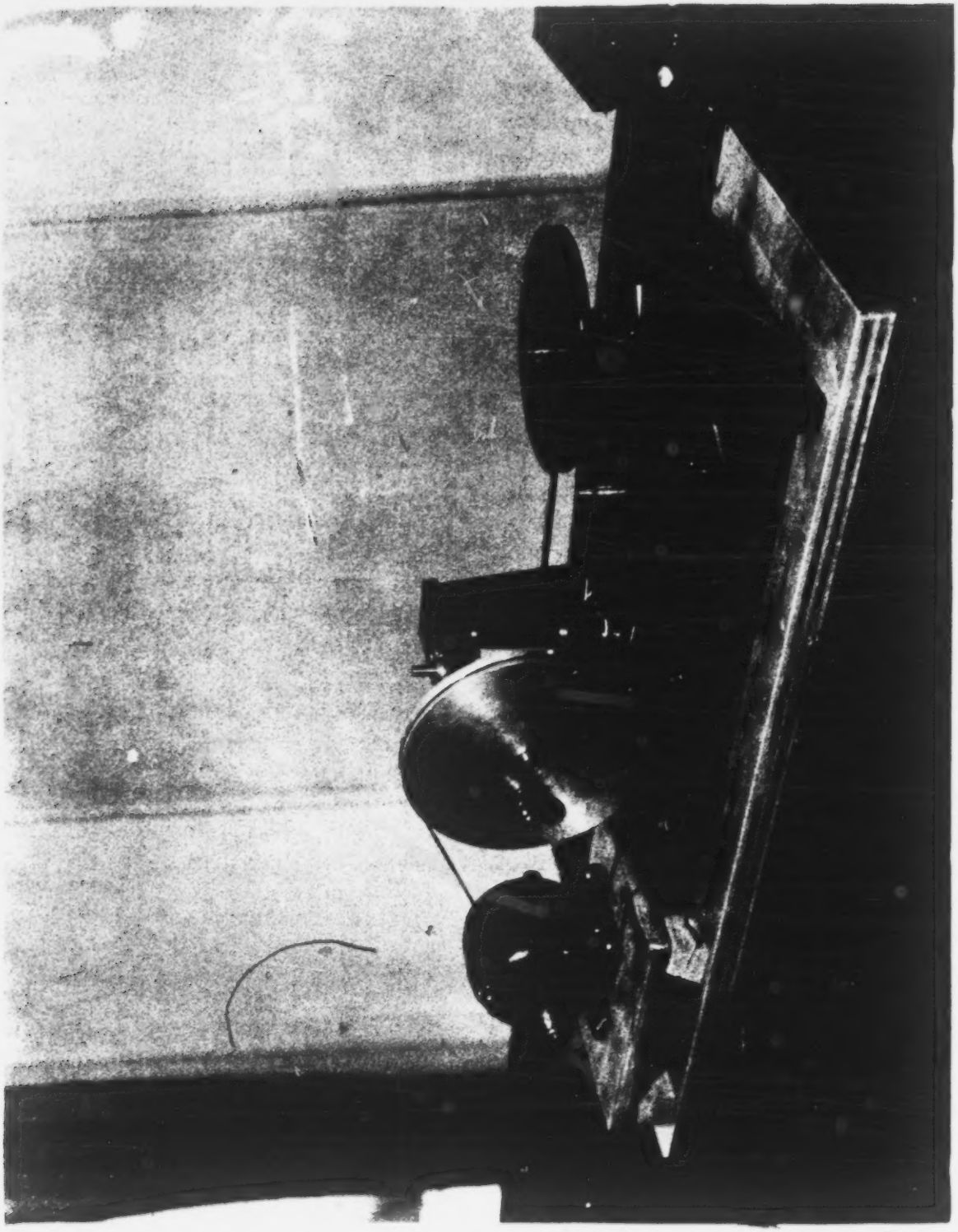
DEFENDANTS' EXHIBIT NO. 84-A.

DEFENDANTS' EXHIBIT NO. 85.

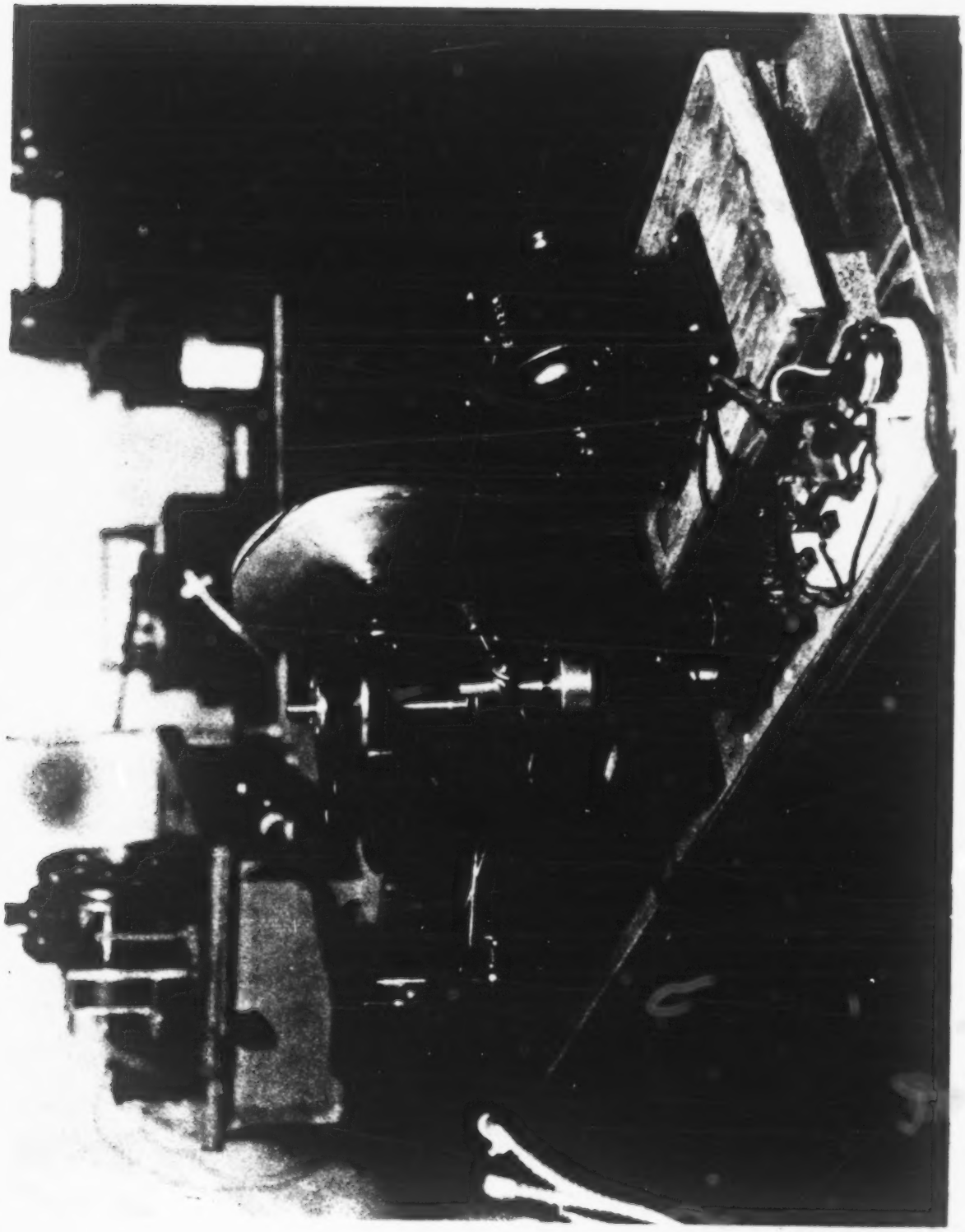
Defendants' Model of Bell & Tainter Patent No. 341,214.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 85-A.



DEFENDANTS' EXHIBIT NO. 85-B.



DEFENDANTS' EXHIBIT NO. 86.

Defendants' Model of French Patent No. 472,467, to Dragoumis, et al.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 86-A.

DEFENDANTS' EXHIBIT NO. 87.

Defendants' Model Referred to as Reel Film Model.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 87-A.

DEFENDANTS' EXHIBIT NO. 88.

Defendants' Model of French Patent No. 414,788 to Compagnie de Phonographe, et al.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 88-A.

DEFENDANTS' EXHIBITS NOS. 89-A TO 89-K.

Cylindrical, Disc and Film Records Used at Defendants' Demonstration.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 89-A.

Cylindrical Record With Speech and Waltz for Edison Kinetophone.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 89-B.

Cylindrical Record With Piano for Edison Kinetophone.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 89-C.

Cylindrical Record With 512 Cycles for Edison Kinetophone.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 89-D.

Cylindrical Record With Speech, Waltz and Piano for Edison Triumph (Defendants' Exhibit No. 31).

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 89-E.

Cylindrical Record With 512 Cycles for Edison Triumph.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 89-F.

Thin Cylindrical Record With Speech for Edison Triumph.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 89-G.

Thin Cylindrical Record Waltz for Edison Triumph.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 89-H.

Film With Speech and Waltz for Reel Film Machine (Defendants' Exhibit No. 87).

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 89-I.

Film Loop With Waltz for Edison Skeleton Machine (Defendants' Exhibit No. 84).

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 89-J.

Film Loop With Speech and March for Dragoumis Machine (Defendants' Exhibit No. 86).

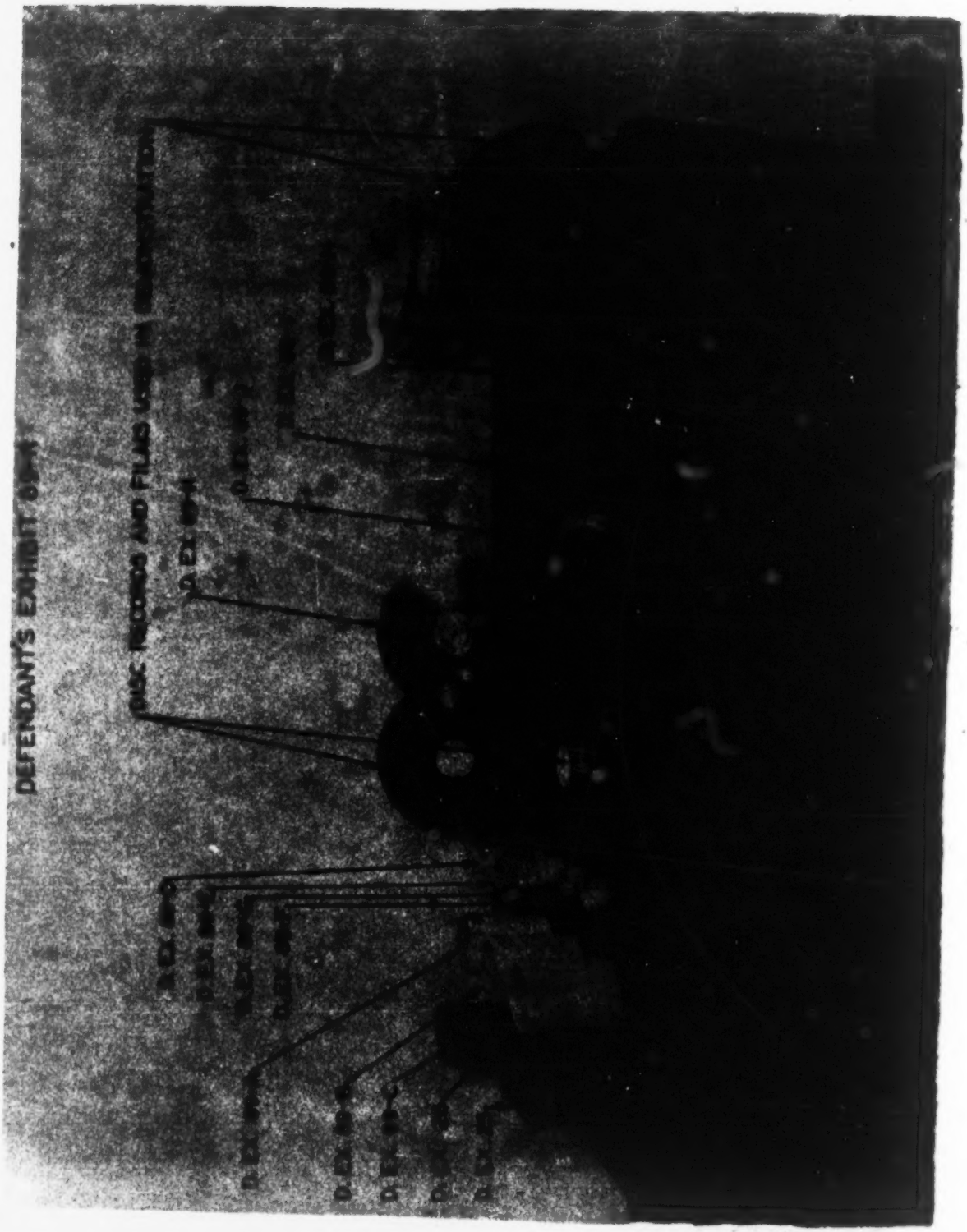
(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 89-K.

Victor Record With Hungarian Rhapsody for General Phonograph and Victrola (Defendants' Exhibits Nos. 88 and 39, Respectively).

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 89-R.

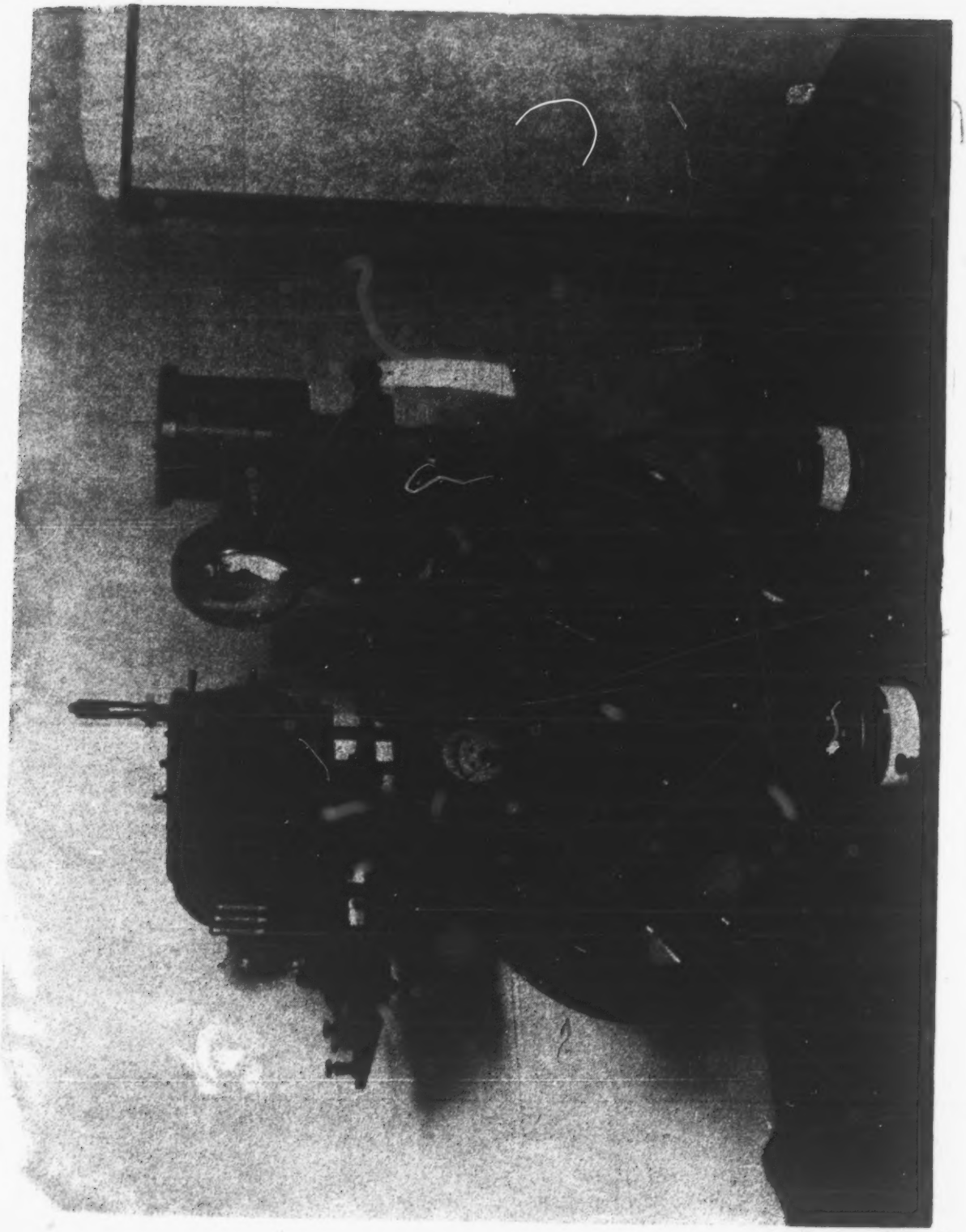


DEFENDANTS' EXHIBIT NO. 89-S.

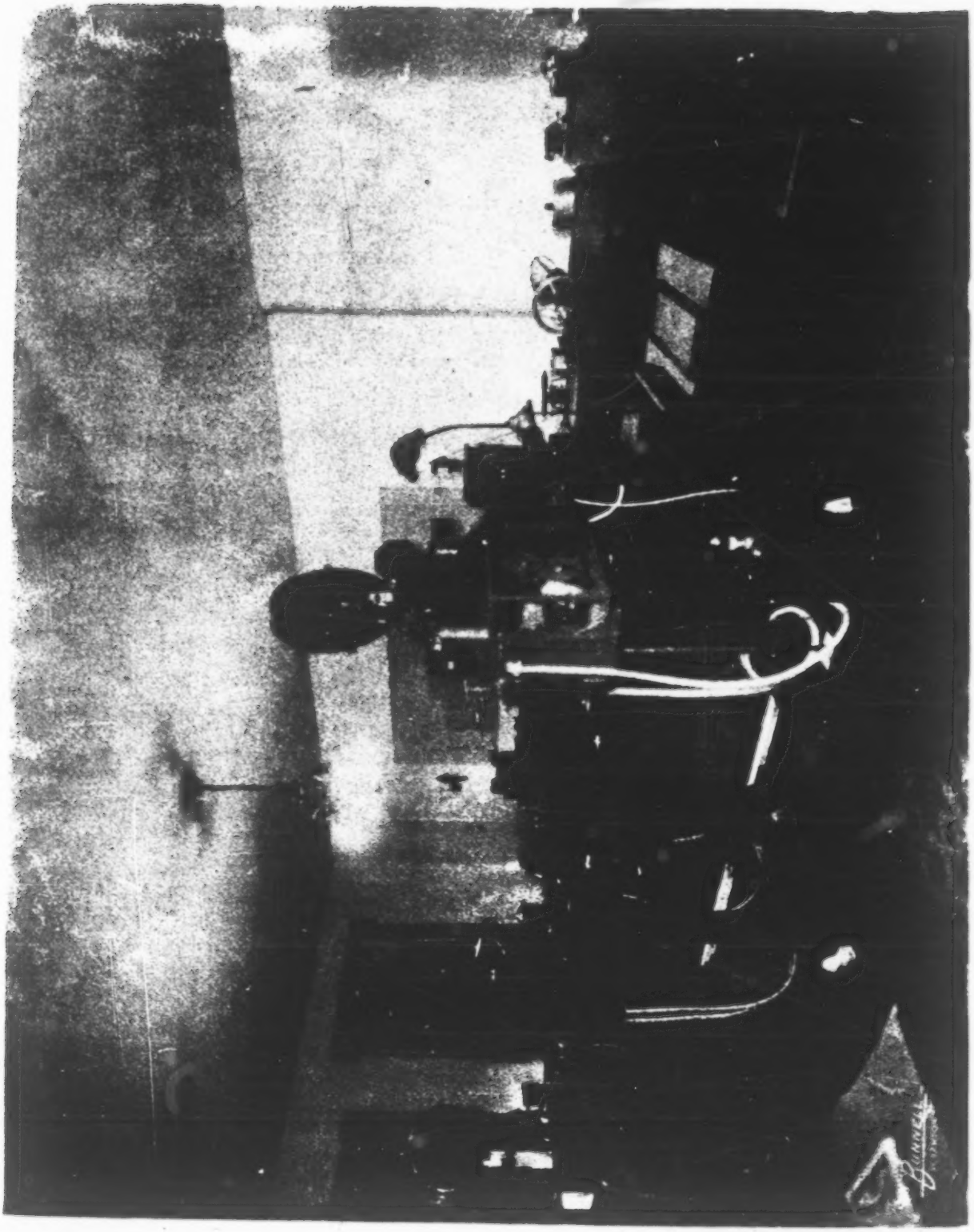
DEFENDANTS' EXHIBIT NO. 89-T.

DEFENDANTS' EXHIBIT NO. 89-U.

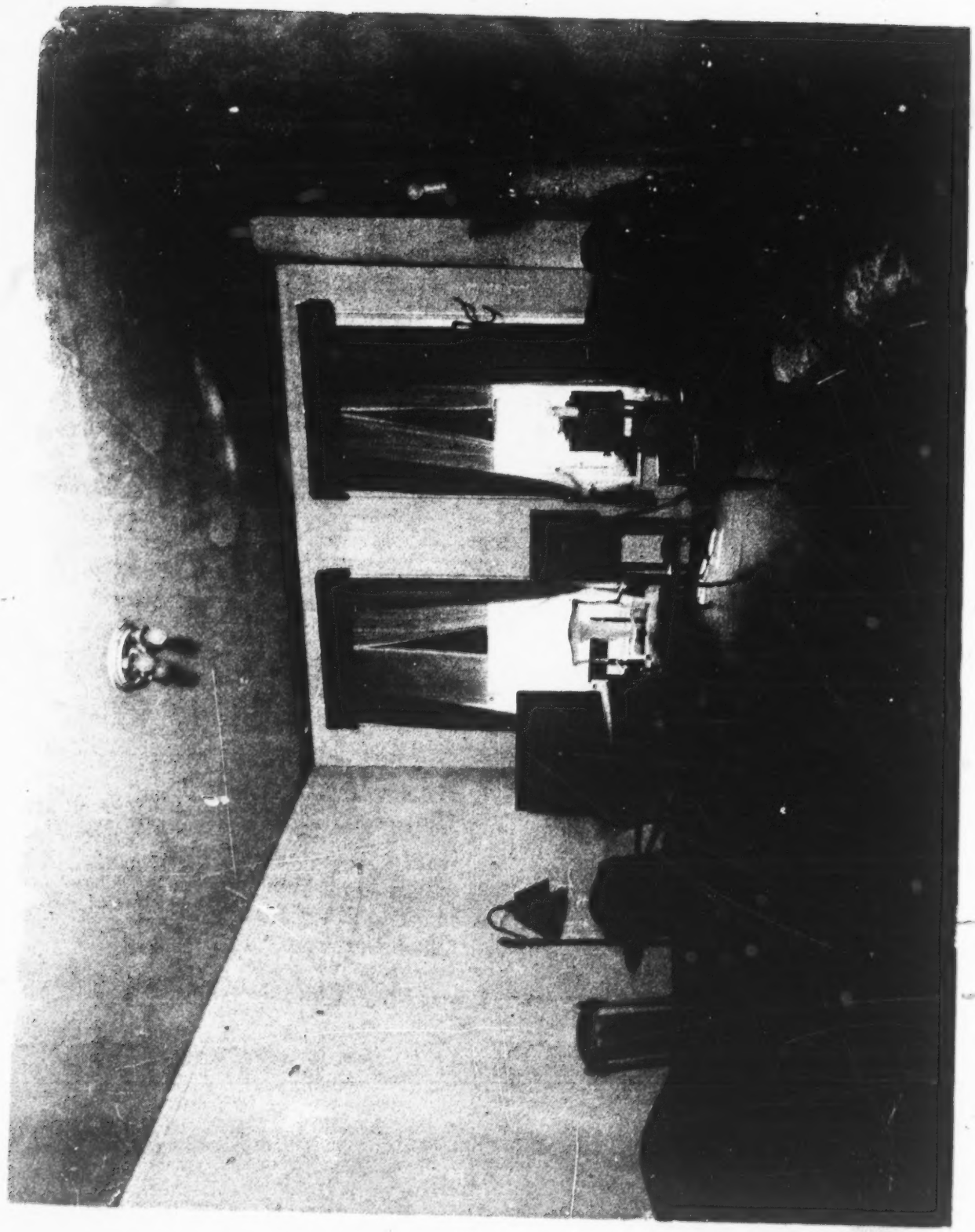
DEFENDANTS' EXHIBIT NO. 89-V.



DEFENDANTS' EXHIBIT NO. 89-W.



DEFENDANTS' EXHIBIT NO. 89-X.



DEFENDANTS' EXHIBITS NOS. 90-A AND 90-B.

File Histories, Including Applications as Originally Filed, of Clark Patents Nos. 1,367,663 and 1,388,515.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 91.

File History, Including Application as Originally Filed, of Constable Patent No. 1,425,177.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 92.

Application as Originally Filed of Trowbridge Patent No. 1,447,913.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 93.

Application as Originally Filed of Rice Patent No. 1,473,976, Granted November 13, 1923, and Rice Patent No. 1,607,480, Granted November 16, 1926, Both Being Based Upon One Application, Serial No. 769,114, Dated March 12, 1913.

(Physical Exhibit.)

1941

DEFENDANTS' EXHIBIT NO. 94.

DEPARTMENT OF COMMERCE
UNITED STATES PATENT OFFICE

To all persons to whom these presents shall come, Greeting:

THIS IS TO CERTIFY that the annexed is a true copy from the records of this office of the Petition, Specification, Oath and Drawings, as originally filed, October 3, 1919, Serial Number 328,299, in the matter of the

Letters Patent of

Aloysius J. Cawley,

Number 1,594,662, Granted August 3, 1926,

for

Improvement in Record Molders.

U. S. DISTRICT COURT
M. D. PENN.
DEFT. EX. 94

IN TESTIMONY WHEREOF I have hereunto set my hand and caused the seal of the Patent Office to be affixed, at the City of Washington, this second day of June, in the year of our Lord one thousand nine hundred and thirty-three and of the Independence of the United States of America the one hundred and fifty-seventh.

ATTEST:

D. F. Gilbelan
Chief of Division.

Thomas E. Robertson
Commissioner of Patents.

11—6058

MAIL ROOM SEP 27 1919 U.S. PATENT OFFICE

PETITION.

[FROM RULES OF PRACTICE, U. S. PATENT OFFICE, PAGE 66, FORM 4.]

To the Commissioner of Patents:

Your petitioner, Aloysius J. Cawley

citizen } *of* The United States
~~*subjects*~~ }

and resident of the City of New York

in the county of New York, *and State of* New York

whose post-office address { *is* } 408 West 115th Street
~~*are*~~ }

pray that Letters Patent may be granted to him

for the improvement in PROCESS OF LATERALLY MODIFYING A SOUND RECORD

as set forth in the annexed specification

And ~~xxx~~ *hereby appoint** X X X

MAIL ROOM OCT U.S. PATENT OFFICE

TO ALL WHOM IT MAY CONCERN:

Be it known that I, Aloysius J. Cawley, a citizen of the United States, and a resident of the City of New York, in the County of New York and State of New York, have invented a new and improved

PROCESS OF LATERALLY MODIFYING A SOUND RECORD,

of which the following is a full, clear and exact description.

This invention relates to the lateral enlargement of photographic, or similar sound records, without any change being made in their length. The resulting record is capable of producing a much louder sound than the original. As the enlargement can be repeated many times, there is no limit to the amplification that may thus be produced. The invention is not limited to enlargement, as in some cases it may be desirable to reduce the record. Moreover, many records other than sound records may be enlarged or reduced by this process, and it is therefore not limited to sound recording.

In carrying out the process, the developed sound record, which is preferably that on the margin of a moving picture film, has placed beneath it a cylindrical lens. Beneath this lens is placed a photosensitive medium. By passing light through the record and lens, the sensitive strip has imprinted upon it an image that is laterally enlarged only. The length, however, is precisely the same as the original. A matrix is then produced, which is capable of impressing a record in relief on the margin of the positive film. It will readily be seen that this process is particularly well adapted to the production of loud and life-like sound records that are in perfect synchronism with the corresponding motion pictures. It overcomes the great draw-back due to the distance of the camera from the persons or objects emitting the sounds which are to be recorded.

For a more complete understanding of the invention, reference is to be had to the following description and claims taken in connection with the accompanying drawings which

illustrate certain embodiments of the invention, and wherein similar reference characters are employed to designate corresponding parts.

Figure 1 is a cross-sectional view of a motion picture film having a sound record on its margin, and having beneath it a photosensitive film. Between these two films is placed a flexible cylindrical lens, the three being mounted upon the sprocket wheel of a film printer. The section is taken through the tooth of the sprocket wheel.

Figure 2 illustrates some of the many different forms the cylindrical lenses, whether flexible, or rigid, may assume. They are cross-sectional views taken at right angles to their length.

Figure 3 is a view of a special apparatus for printing the films, while holding them any desired distance apart, and thus securing a comparatively large projection. The films are moved at precisely the same speed by the device shown to insure exact register.

Figure 4 is a view of a developed sensitive strip with its laterally enlarged record, and also the margin of the negative film containing the original record.

Figure 5 shows three crosssectional views of matrices, the lower one being made from the central figure.

Figure 6 is an elevation of a combined picture printer and sound record printer, capable of giving the sound record a vastly greater exposureto the light than the picture record. This is to permit the two records to be printed in one operation at the same speed ordinary motion pictures are printed.

Figure 7 is an end view of a specially designed sprocket wheel intended to produce a more perfect recording and reproduction of sounds on motion picture films.

Figure 8 is cross-section of this on the line 77. the reproducer is not shown in cross section, however.

Figure 9 is a cross-sectional view of a motion

picture film with its corresponding sound record matrix cemented to its margin. This greatly facilitates the simultaneous printing of the pictures and impressing of the sound record.

Figure 10 is a view of an apparatus for printing the pictures and impressing the sound record in one operation by means of the combined film and matrix.

A photosensitive strip, such as one consisting of gelatine treated with potassium bichromate, is placed upon the sprocket wheels of a film-printer, as shown in Figure1, where C is the sensitive strip provided with sprocket holes. 1 is a tooth of a sprocket wheel. Over this strip is placed the cylindrical lens B, also provided with sprocket holes in its margin. This lens is provided with a rather large space 6, which is intended to give the light rays an opportunity to diverge or converge, according to the nature of the lens used. A greater enlargement or reduction is thus produced. The negative film A with its sound record 2 in the gelatine coating 4, is placed above the cylindrical lens. The celluloid of the film is shown at 3. A source of light is placed above and the strip C is printed. By providing a flexible lens as shown in this figure, it may be passed through any kind of picture printer. The lenses, whether flexible or rigid, may have any cross-sectional form desired; some are shown in Fig. 2. They may also be made of different refractive media to compensate for defects of lenses made of one medium alone. The square projections or spacers serve to keep the negative film and sensitive strip at an exact distance at all times. Those spacers are shown at 7 in Figures 1 and 2.

Asthe sound record will be printed upon a much less sensitive substance than that upon which the picture record is printed, a much longer exposure will be required for the sound record than the picture record. Figure 3 illustrates one method of meeting this difficulty. 8 represents a mercury vapor arc, whose light passes through the diaphragm

by means of a long narrow opening of variable length. This diaphragm 9 and a suitable casing are intended to exclude all other light from the film. A transparent guide plate 10 holds the negative film A at any desired position; this is accomplished by means of a rack and pinion. Plate 11 accomplishes a similar result for film C upon which the record is to be printed. The films are moved by means of the sprocket wheels 12 to the right where film A enters a picture printer where it is in contact with its positive film. The sensitive strip C also passes to the right where it is wound upon its reel to be later developed. Guiding rolls are shown at 15 and 15'. Rigidly attached to the sprocketwheels are the wheels 13, each provided with friction rims 14. These serve to keep the two films in exact register. Pinion wheels may be substituted for these, if desired. The cylindrical lens is shown at B, and is of the rigid type.

In Figure 4, A is supposed to represent the margin torn from a negative film. The developed sound record is shown at 18, while 19' represents a sprocket hole. The laterally enlarged copy of this record is shown at 16 upon the strip 17 containing the sprocket holes 19. It will be readily seen that this copy is of precisely the same length as the original record, but its undulations corresponding to the amplitude of the sound waves it may reproduce are enlarged. This is a great advantage in motion picture work, as the sound record is amplified without any increase in the length of the film. The record 16 is supposed to be in the form of a raised ridge or depressed groove, according to the nature of the treatment accorded the bichromated gelatin, or similar substance composing it. It is to be particularly noted that by printing the record upon a photosensitive silver film, and developing it, and printing from it in turn, and continuing this process repeatedly, there is practically no limit to the amount of enlargement or reduction that can be produced. The final printing is, of course, made upon a substance capa-

ble of producing a record in relief when developed. Of course silver negatives and positives will be produced alternately, in which the line or record will be white and black in turn. The bichromated gelatine film is printed from a print that is similar to the original record for this reason. It is thus seen that an almost inaudible sound record produced on a motion picture film in a camera can be amplified so that any degree of loudness may be attained. Accordingly, the sound record corresponding to a picture can be modified to produce the most desirable sound intensity in the theatre.

The photosensitive strip from which the matrix is to be made may be subjected to different treatments so that either a ridge or groove is produced where the record line is printed. For instance, the first view in Fig.8 shows a bichromated gelatin strip which has been treated with cold water in the well known manner. This has caused the ridge 20 to be raised upon its surface. This may be hardened by means of chrome alum, tannic acid, formalin, alum, or similar substances. It may be used directly as a matrix to impress a groove on a celluloid, or similar film. If a silver haloid strip be used, the silver line on the margin of the negative film may be built up chemically so as to form a raised ridge. This ridge on the negative film may be used directly as a matrix. If the bichromated gelatin be treated with warm water, the unaltered material is dissolved out and the groove 21 is produced. If a silver haloid strip is used, the metallic silver of the record line may be dissolved out by chemical treatment, for instance with nitric acid. In either case, after thoroughly drying and hardening the strip, it is placed in contact with a ribbon of soft metal, such as lead, and pressure applied by rolls, etc., and a metallic matrix 23 having a ridge 22 obtained. This may be used to impress the record upon the margin of the positives.

An elevation of a combined picture printer and sound record printer is shown in figure 6. This is particularly

designed to give an exposure to the sound record that is many times as long as that given the picture record without lowering the speed of ordinary motion picture printing. The negative film A together with the cylindrical lens B and sensitive strip C passes over the curved plate 11 toward the left. During this passage, light from the mercury vapor arc 8 pa ses through the long narrow aperture in the diaphragm 9 and acts upon the sensitive strip C. By operating the slides 30, the length of the aperture, and consequently of the exposure, is varied. After this exposure the negative film A passes over the sprocket 25 of the picture printing part of the apparatus. It is held in close contact with the positive strip 26 by means of the guiding rolls 27. Both films pass upwards into the printer, which is not shown in full in the drawing, as it is the same as any ordinary picture printer. The cylindrical lens B is of the flexible belt type, and is therefore in the form of an endless band. It passes downwards over its guiding rolls 28, thence to the right and upwards, where it again meets a new portion of the negative film. The strip C coming from its reel 29' is later wound upon reel 29. If desired, the light 8 may be placed beneath plate 11 and the latter made of glass. The position of the films would then be reversed, and the diaphragm placed beneath the plate 11. Printing could then be done from below. The light tube 8 could be curved to correspond to that of plate 11 in order to insure uniform illumination, if desired. Or, the sphericity of glass plate 11 could be increased so that it would become a glass cylinder. The light tube could be placed at the axis of this cylinder and at right angles to the direction of motion of the films. The films can pass around this cylinder spirally one or more times, thus greatly increasing the exposure. The glass cylinder could rotate on its axis.

It is thought that the pressure upon the films and lens produced by the tension of film A will be sufficient to hold them in register. The plate 11 is supposed to have a guiding groove in its surface. However, contact rolls may be placed against the upper surface of film A if desired. It is also to be understood that a rigid lens of glass may be used provided with guiding grooves to hold the films in proper register. The flexible lens may be made of celluloid, gelatin, etc. It is to have a strip attached to it, or forming one piece with it, having sprocket holes to engage with the teeth on the guiding rolls or sprockets.

In practice it is highly desirable that the film should be held perfectly rigid while moving at an absolutely uniform rate of speed. Figure 7 is an end view of a device intended to produce this. It shows the sound record being reproduced in the projector. The positive film 26 is held in firm contact with a large sprocket wheel 36 which is provided with an adhesive ring 35. This is made of hard rubber coated with a rubber paint on its surface. Or it could be made of any phonograph record backing material to which an adhesive material is added. The rings extend upward from the steel body through this cushion to form a base for the sprocket teeth. This constitutes almost the exact equivalent of a cylindrical phonographic record upon its mandrel. The stylus is shown at 31 and the reproducer, which is really a microphone and reproducer combined is shown at 32. The electric power is supplied from 34, which should be a direct current dynamo or storage battery, as it is desired to obtain a loud, powerful reproduction. The wires lead to a loud speaking telephone receiver located near or behind the picture screen. An induction coil, or transformer may be included in the circuit, and also sound amplifiers of the vacuum bulb type which have been successfully used with wireless telephony, in order to increase the sound intensity. The rolls 28 hold the film in firm contact. This type of sprocket is intended both for recording and reproducing the sounds.

Line 30, the word screen was J.J.C. 9-19-19

After printing the picture record and sound record in one operation by the device shown in figure 6, we have a positive picture film and a sound matrix, both of which were simultaneously developed and fixed. It is then only necessary to pass the two in contact through heated rolls under pressure. But in practice many positives are produced from the same negative. In order to facilitate this and also to afford convenience in handling and storing and also to avoid error in printing sound and picture records in proper register, the matrix D is cemented to the negative film margin as shown in Figure 8. The utility of this will be better appreciated by a study of the next figure.

Figure 10 is a view of a device intended to print a positive picture film from the negative film A and at the same time impress the sound record in the film. The combined negative and matrix shown in Figure 9 is utilized in this apparatus. The reel 43 containing the positive film is placed on the spindle 47', and the reel 44 containing the negative film with its matrix D is placed on the spindle 47. Ordinarily the celluloid faces of the films will be thus facing each other, but in case they are not, one or both reels may be turned round, and the film passed over the guiding roll 48 or 48'. In any event, the film will always in a nearly vertical position as shown in the drawing. The films pass between the heated rolls 40 and 40', where pressure is applied in order that the matrix may leave its impression in the celluloid. On their way to those heated rolls the films pass close to, or in direct contact with the metal chamber 41 containing steam or hot water. This insures the films being brought up to the plastic temperature without any necessity of reducing the usual printing speed of the picture printing portion of the apparatus. The films then take opposite directions and pass over guiding rolls 45 and 45', and from thence to the picture printer. This is not all illustrated in the drawing, as any ordinary picture printer can be used here.

The only alteration that is necessary is to provide a groove 46 in all of its sprocket wheels as well as in the film gate. This is to permit the passage of the matrix without any possible injury to it. The main sprocket of the printer is shown at 25 with its guiding rolls 27 and groove 46. This sprocket is directly under the film gate. A cross-section of t is sprocket is shown also. This illustrates the manner in which the matrix D fits into the groove 46, while the gelatin faces of the negative film A and the positive film 26 are in contact during the process of printing. After being exposed at the film gate to the light, the two films pass upwards and are wound upon their respective reels in the usual manner. The positive is then developed and is ready for the reproduction of both pictures and sounds. The sprocket 25 and heated rolls 40,40' are rigidly connected by a suitable gearing, such as a belt, or sprocket chain, so that the film moves at a uniform speed throughout the apparatus. The guiding rolls 45,45' may, therefore, be dispensed with, if desired. It was not thought necessary to show this gearing, as it would tend to obscure the drawing. Two intermeshing pinions could be provided between the heated rolls and the sprocket 25 to insure the proper speed. The rolls and chamber 41 are connected by suitable piping to a source of steam or other heating medium. In the drawing, the films are supposed to pass downward over the heated chamber and through the heated rolls; after this, they pass to the printer at the top. But the order can be reversed, if desired. In which case it would be necessary to provide the heated chamber below the rolls 40 and 40'. Chambers could be provided in both positions and the steam or hot water turned into either according to the direction of motion of the film. It is desirable to heat the matrix as well as the positive film in order to obtain a more satisfactory impression. The power is preferably applied directly to the heated rolls, while they in turn drive the sprocket 25 of the picture printer.

It is to be understood that, where desirable, reels are provided with the regular grooved pulley and cord belt in order to insure proper winding of film.

In the picture and matrix printer shown in Fig. 6, a driving sprocket may be attached to the two films and flexible lens at any point where the three are in contact, as between plate 11 and guiding rolls 28. This sprocket would be rigidly connected by suitable gearing, such as gear wheels or sprocket chains, to wheel 25 of the picture-printing portion of the apparatus. It is thought that the light coming from the mercury vapor arc would have sufficiently great intensity to print the picture record of the film from its position as shown in the drawing, as the silver compound is much quicker in printing than the bichromated gelatine. However, if desired, the picture printer could be placed parallel to the glass plate and on the opposite side of the arc tube. Or the arrangement could be as shown, but a mirror added to reflect the rays to the point desired.

By attaching the matrix directly to the negative and by further using the devices shown in Figs. 6 and 10, the difficulties which would ordinarily arise from the use of many feet of metallic or gelatine ribbon, are greatly minimized. Moreover, by means of identification marks on the films, strips and matrices when printing and impressing, the errors due to improper register will be practically eliminated, and perfect synchronism of picture and sound record secured. Also the above mentioned apparatus, besides accomplishing the above desirable objects, combine several tedius and lothersome operations into one. Fig. 6 combines the printing of the strip from which the matrix is finally to be produced and the printing of the picture record on the first positive. The strip is developed and matrix produced while the positive film is being developed; much time is thus saved. The latter is then run through the sound molder and picture printer shown in Fig.10, but of course only the sound record is impressed. All subsequent positives, required to

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supply film exchanges, etc., have their picture record printed and sound record molded in one operation; it only remains to develop the picture record. If desired, during this latter operation, an adhesive water-proof tape can be cemented over the sound groove in order to protect it from the developing bath. Or, it could be coated with any waxlike substance. This will probably be unnecessary, however. By combining those various processes to produce unitary results, an immense amount of time and trouble is saved, and possibility of errors greatly reduced.

The sound record obtained in the camera may be an extremely faint, hair-like line, whose undulations may be practically indiscernable to the eye. It will probably be produced photochemically by an extremely fine stylus. By magnifying it laterally, by repeated printings until it is of sufficient amplitude to produce a matrix, it can be made as powerful as desired. The fact that the lateral enlargement also broadens the sound line is not a defect, as it permits the use of a stronger reproducing stylus.

It is to be noted that the light in printing the picture record does not reach the margin where the sound record is to be printed, and also that the light used in printing the sound record does not touch the picture portion of the sensitive film. This accomplished by providing suitable partitions. However, where a strip of sufficiently sensitive material is used for the sound matrix print so that both records can be printed in an ordinary picture printer, the light is permitted to impinge upon both simultaneously by means of suitable apertures.

The word "record" is intended obviously to mean any record, whether of sounds or not, that will lend itself to the herein described process of lateral enlargement or reduction. For instance, it may be a wavy line produced by a scientific instrument.

The invention is not limited to enlargement, as in practice it may be sometimes desirable to reduce it. For this reason, I have used the expression "laterally modified" in the appended claims, in order to show clearly that the record may be either enlarged or reduced. If I merely used the word "enlarged", I would not properly designate the full scope of the invention.

The word "copy" is intended to mean any type of photographic copy, such as a silver print, etc., but particularly an embossed copy, or copy in relief, such as those produced by means of bichromated gelatine films.

Developing is intended to convey the broadest possible meaning of this word. It comprises any kind of developing, and includes fixing, etc. In short, it implies the production of the record, copy. etc.

Having thus described my invention, I claim as new and desire to secure by Letters Patent,

1.-The herein described process of laterally modifying records, which consists in placing a cylindrical lens between a record and a photosensitive medium during the process of printing; developing said medium to produce a laterally modified copy of said record.

2.-The herein described process of laterally modifying sound records, which consists in placing a cylindrical lens between a sound record and a photosensitive medium while printing; developing said medium to produce a laterally modified copy of said sound record.

3.-The herein described process of laterally modifying sound records, which consists in placing a cylindrical lens between a moving picture film margin carrying a sound record, and a photosensitive medium while printing; developing said medium to produce a laterally modified copy of said sound record.

4.-The herein described process of laterally modifying sound records, which consists in placing a felxible cylindrical lens between a moving picture film margin having a sound record upon it, and a photosensitive medium while printing; developing said medium to produce a laterally modified copy of said sound record.

5.-The herein described process of laterally modifying sound records, which consists in placing a flexible cylindrical lens between a moving picture film margin carrying a sound record, and a photosensitive medium while said film with its attendant positive is passing through a picture printing device; exposing sound and picture records to light simultaneously, developing said medium to produce laterally modified copy of said sound record.

6.-The herein described process of laterally modifyin sound records, which consists in placing a cylindrical lens between a moving picture film margin carrying a sound record, and a photosensitive medium while said film is passing to or from a picture printing device; exposing said margin to a light source for a variable portion of its length to give a greater exposure to the sound record than to the picture record without decreasing the usual picture printing speed.

7.-The herein described process of making records, which consists in subjecting a moving picture film margin and matrix in contact to heat and pressure; passing them through a picture printing device, printing and developing to produce a combined picture and sound record.

8.-The herein described process of making records, which consists in passing a combined picture film and matrix in contact with a positive film through a picture printing device and printing the picture record; changing their direction of action so as to bring the matrix in contact with the positive film without spirally twisting either, subjecting

them to heat and pressure and developing the picture record to produce a combined picture and sound record.

9.-The herein described motion picture sprocket wheel, which consists of a steel body provided with a semi-resilient, slightly adhesive ring through which steel teeth project.

10.-The herein described motion picture sprocket wheel, which consists of a steel body provided with a semi-resilient, slightly adhesive ring, through which steel teeth project, and provided with pressure rolls for holding film in close contact with the greater part of its circumference.

11.-The herein described combined printer, which consists of a picture printing device connected by suitable gearing to a sound matrix printing device, so that they function as a single unit and at the same film speed.

12.-The herein described combined picture and matrix printer, which consists of a picture printing device connected by suitable gearing to a sound matrix printer provided with a variable light aperture, so that they function as a single unit and at the same film speed.

13.-The herein described combined printer, which consists of a picture printing device connected by suitable gearing to a sound matrix printing device provided with a variable diaphragm slit and curved plate, so that they function as a single unit and at the same film speed.

14.-The herein described picture and matrix printer, which consists of a picture printing device connected by suitable gearing to a sound matrix printer provided with a variable light aperture, a curved plate and cylindrical lens, so that they function as a single unit and at the same film speed.

15.-The herein described combined picture and matrix printer, which consists of a picture printing device connected by suitable gearing to a sound matrix printing de-

vice provided with a variable light aperture and cylindrical lens, so that they function as a single unit and at the same film speed.

16.-The herein described motion picture negative film having attached to it a matrix capable of impressing its corresponding sound record.

17.-Therein described cylindrical lens provided with juxtaposed spacers having parallel, equi-distant sides, to hold printing surface at uniform distance from negative.

18.-The herein described cylindrical lens provided with a projecting space to permit rays to converge or diverge.

19.-The herein described cylindrical lens provided with parallel-faced spacers at either side and a projecting space above or below.

20.-The herein described flexible cylindrical lens.

21.-The herein described flexible cylindrical lens having its ends joined so as to form a continuous belt.

22.-The herein described flexible cylindrical lens having a margin provided with sprocket holes.

23.-The herein described flexible cylindrical lens having sprocket holes at margin, a projecting space suitably located and ends joined to form endless belt.

24.-The herein described combined picture printer and sound record molder consisting of a picture printing device connected by suitable gearing to a sound record molding apparatus so that they function as a single unit and at the same film speed.

25.-The herein described combined picture printer and sound record molder, consisting of a picture printing device connected by suitable gearing to heat-pressure rolls for the purpose of producing a combined sound and picture record at the usual picture-printing speed.

26.-The herein described combined picture printer and sound record molder consisting of a picture printing de-

vice connected by suitable gearing to heat-pressure rolls and means for contacting opposite faces of films alternately.

27.-The herein described combined picture printer and sound record molder consisting of a picture printing device connected by suitable gearing to heated rolls under pressure, a suitably placed heater 41, and means for contacting opposite faces of films alternately, so that all function in a unitary manner and at the same film speed.

28.-The herein described combined picture printer and sound record molder, consisting of a picture printing device connected by suitable gearing to heat-pressure rolls, means for contacting opposite film faces alternately, and suitably placed grooved sprockets and grooved film gates.

29.-The herein described combined picture printer and sound record molder consisting of a picture printing device connected by suitable gearing to heat-pressure rolls, a suitably placed heater, means for contacting opposite film faces alternately, reel pivots and suitably placed grooved sprockets and film gates.

30.-The herein described combined picture printer and sound record molder consisting of a picture printing device connected by suitable gearing to heat-pressure rolls with peripheral sprocket teeth, a suitably placed heater, means for contacting opposite film faces alternately, suitably placed reel pivots and guiding rolls and suitably placed grooves.

Algernon J. Warbig

1514

OATH

To accompany an application for United States Patent.

State of New York }
County of New York } ss:

Aloysius J. Cawley

MAIL ROOM OCT 1919 U.S. PATENT OFFICE

the above-named petitioner, being sworn (or affirmed), depose s and say s that he is a citizen of the United States of America; and resident of New York, in the Count of New York, and State of New York, that he verily believe s himself to be the original, first, and sole inventor of the improvement in PROCESS OF LATERALLY MODIFYING A SOUND RECORD described and claimed in the annexed specification; that he do es not know and do es not believe that the same was ever known or used before his invention or discovery thereof, or patented or described in any printed publication in any country before his invention or discovery thereof, or more than two years prior to this application, or in public use or on sale in the United States for more than two years prior to this application; that said invention has not been patented in any country foreign to the United States on an application filed by him or his legal representatives or assigns more than twelve months prior to this application; and that no application for patent on said improvement has been filed by him or his representatives or assigns in any country foreign to the United States, [redacted]

(The acknowledgment may be made by any citizen speaking in the case.)

Inventor's full name: Aloysius J. Cawley

Sworn to and subscribed before me this 2nd day of October, 1919.

Dominick A. Ecr
(Signature of judge or notary.)
30 Nelson Terrace
Address.

Oath will be made by the administrator; if insane, by the guardian, conservator, or legal representative. If will declare his belief that the party named as inventor was the original and first inventor.
Insert "the United States of America," and state of what foreign country he is a citizen or subject.
Insert "a resident of ——, in the county of ——, and State of ——," or "No. —— street, in the city of ——, (Kingdom, Republic, or Empire) of ——."
If a divisional application has been filed, and in each case give date of filing the same. If no application has been filed, strike out the words "
All erasures must be initialed.
"When the person before whom oath or affirmation is made is not provided with a seal, his official character shall be established by competent evidence, as by a certificate from a clerk of a court of record or other proper officer having a seal."
All the application papers must be fastened together with a ribbon or tape, the ends of which must be brought together under the seal before the latter is affixed and impressed; or, each sheet must be impressed with seal, or initialed by the officer. The drawing must not be attached to the papers.
When the oath is taken abroad before a notary public, judge, or magistrate, his authority should in each instance be proved by a certificate of a diplomatic or consular officer of the United States.

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Fig.1.

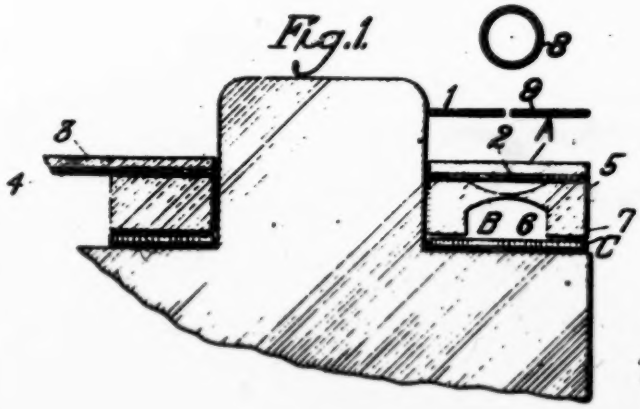


Fig.2.

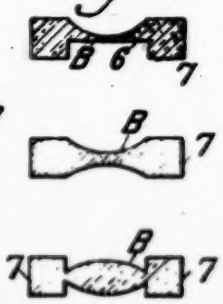


Fig.3.

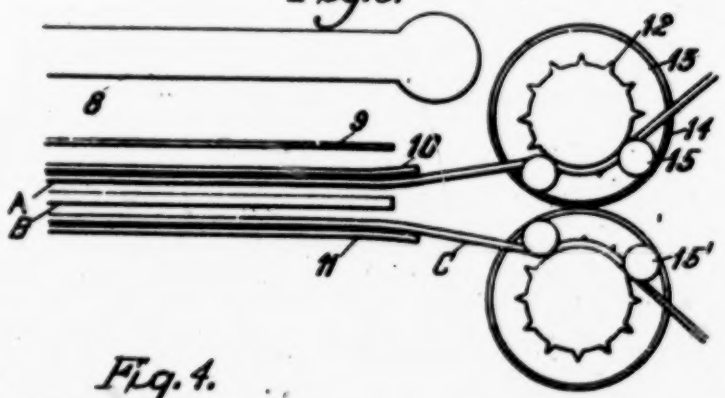


Fig.4.

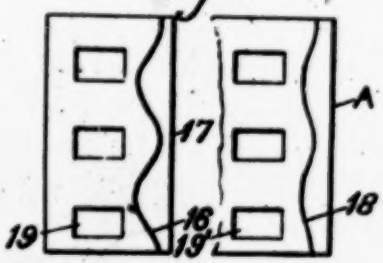


Fig.5.

WITNESSES
Charles F. Blum
Frederic H. Ebb

INVENTOR.
Algernon J. Crawley

328299-2

Fig. 6.

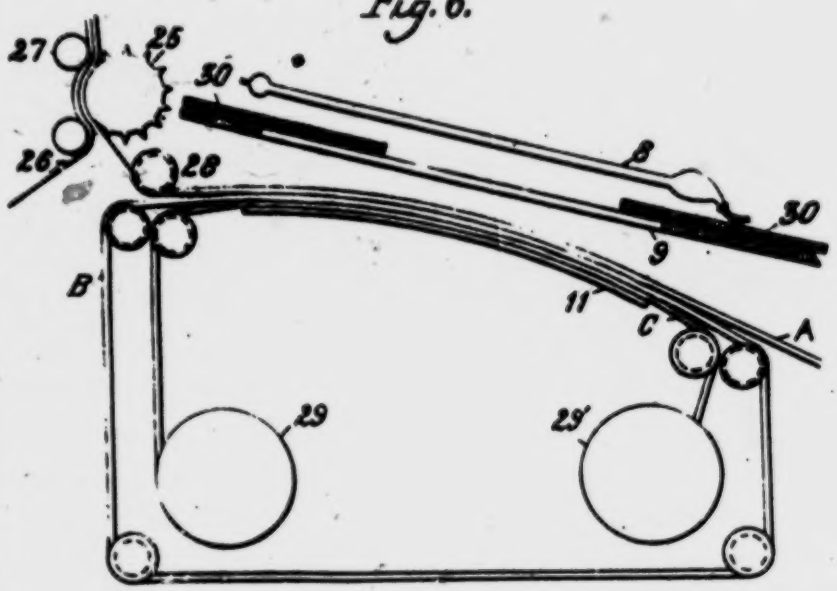


Fig. 7.

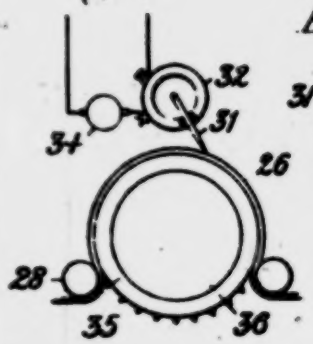


Fig. 8.

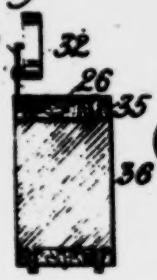


Fig. 9.

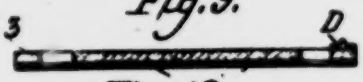
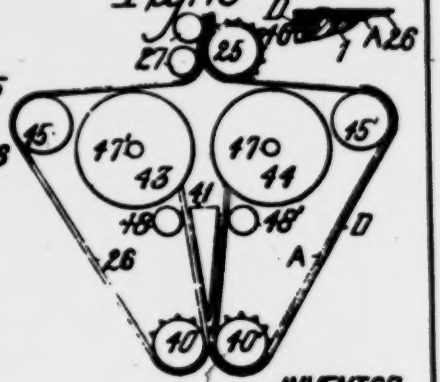


Fig. 10



WITNESSES

Edmund F. Allen

Frederick W. Erb

INVENTOR

Stephen J. Crowley

DEFENDANTS' EXHIBIT NO. 95.

390

DEPARTMENT OF COMMERCE
UNITED STATES PATENT OFFICE

To all persons to whom these presents shall come, Greeting:

THIS IS TO CERTIFY that the annexed is a true copy from the records of this office of the Petition, Specification, Oath and Drawings, as originally filed, January 8, 1921, Serial Number 435,984, in the matter of the

Letters Patent of

Aloysius J. Cawley, Assignor to
Radio Corporation of America,

Number 1,825,441, Granted September 29, 1931,

for

Improvement in Sound Recording Processes and Apparatus.

U. S. DISTRICT COURT
M. D. PENN.
DEFT. EX. 95

IN TESTIMONY WHEREOF I have hereunto set my hand and caused the seal of the Patent Office to be affixed, at the City of Washington, this eighteenth day of March, in the year of our Lord one thousand nine hundred and thirty-two and of the Independence of the United States of America the one hundred and fifty-sixth.

ATTEST:

Chief of Division. *Thomas E. Robertson*
Commissioner of Patents.

11—3628

1518

MAR 1920 U.S. PATENT OFFICE

PETITION.

(FROM RULES OF PRACTICE, U. S. PATENT OFFICE, PAGE 66, FORM 4.

To the Commissioner of Patents:

Your petitioner Aloysius J. Cawley,

citizen ~~subject~~ } *of* The United States

and resident of New York

in the county of New York, *and State of* New York

whose post-office address is 408 W. 115th Street,

prays that Letters Patent may be granted to him

for the improvement in PROCESS OF HIGH SPEED SOUND RECORDING ON LOW SPEED MEDIA.

as set forth in the annexed specification

And ~~XXXXXXX~~ *hereby appoint** ~~XXXXXX

OATH

3-080.

To accompany an application for United States Patent.

County of New York
State of New York } ss:

Aloysius J. Cawley,

the above-named petitioner, being sworn (or affirmed), depose s and say s that he is citizen of the United States of America' and resident of' New York, County of New York and State of New York, that he verily believe s himself to be the original, first, and' sole inventor of the improvement in' PROCESS OF HIGH SPEED SOUND RECORDING ON LOW SPEED MEDIA described and claimed in the annexed specification; that he do es not know and do es not believe that the same was ever known or used before his invention or discovery thereof, or patented or described in any printed publication in any country before his invention or discovery thereof, or more than two years prior to this application, or in public use or on sale in the United States for more than two years prior to this application; that said invention has not been patented in any country foreign to the United States on an application filed by him or his legal representatives or assigns more than twelve months prior to this application; and that no application for patent on said improvement has been filed by him or his representatives or assigns in any country foreign to the United States, EXCEPTED

(No acknowledgment may be made by any attorney appearing in the case.)

Inventor's full name:' Aloysius J. Cawley

Sworn to and subscribed before me this 17th day of January, 1952

J. D. Sinn
Notary Public
(official character.)

The oath will be made by the administrator; if insane, by the guardian, conservator, or legal representative, and will declare his belief that the party named as inventor was the original and first inventor. Persons who have resided in the United States will be described as "a resident of ——, in the county of ——, and State of ——," or "of No. —— street, in the city of ——," and all others as "a subject of the King (Kingdom, Republic, or Empire) of ——."

In cases in which an application has been filed, and in such case give date of filing the same. If no application has been filed, the oath will be made except as follows."

The jurat will be the signature of the affiant.

If the person before whom the oath or affirmation is made is not provided with a seal, his official character shall be authenticated, as by a certificate from a clerk of a court of record or other proper officer having a seal."

All papers must be attached together with a ribbon or tape, the ends of which must be brought together under the seal before the same is affixed and impressed; or, each sheet must be impressed with seal, or initialed by the officer. The drawing must not be attached to the papers.

When the oath is taken abroad before a notary public, judge, or magistrate, his authority should in each instance be proved by a certificate of a diplomatic or consular officer of the United States.

TO ALL WHOM IT MAY CONCERN;

Be it known hat I, Aloysius J. Cawley, a citizen of the United States, and a resident of New York, in the County of New York and State of New York, have invented a new and improved

PROCESS OF HIGH SPEED SOUND RECORDING ON LOW SPEED MEDIA,

of which the following is a full, clear and exact description:

The invention relates generally to the method of producing sound records on motion picture films, so that sound and picture records may be synchronously reproduced, although the invention is not necessarily limited to this field.

More particularly, the invention is concerned with the recording of sound on a motion picture film at a recording speed that is much in excess of the speed of the film. An arrangement is provided whereby a recorder contacts with a film, while moving in the opposite direction thereto. The recording speed is thus equal to the sum of the speeds of the recorder and film.

A plurality of recorders are employed, which contact alternately with separate portions of the film. These recorders are placed radially at fixed intervals, and one contacts with a record surface of a given length, while the film has actually passed through but a fraction of this length. The other recorder is then in a position to contact with an equivalent length juxtaposed to, or opposite to that traversed by the first.

An electrical or mechanical arrangement is provided whereby the recorders are thrown out of operation when not recording their own specific record groove.

Arrangements are described whereby any desired sound recording speed may be obtained without any increase in the

the speed of the film, by simply increasing the number and speed of the recording units.

The invention is perfectly adaptable to the standard motion picture film as it exists in practice at present, and is concerned with placing of sound records on the margin, or margins of such a film. This is particularly feasible if mechanical sound grooves are used, as there is room for a very large number of such records. The latter may be placed on one margin only, or be distributed on both margins, as hereinafter described.

As the sound records are intended to be placed on the margins of the film, there is no interference of picture and sound record as would be the case, if for instance, the latter were placed across the reverse face of the film, as in such case, they would be projected upon the picture screen.

The invention, further, is not limited to mere mechanical methods of recording, but is adapted to any means, such as photographic, magnetic, or the electrical reproduction described in another application that I am about to file. Although the invention is not limited to any of those methods, great emphasis is placed on the method employing electrically operated mechanical sound recorders and reproducers; the recording speed that it is most desired to use with this is approximately double the film speed.

It will be noted that there are no abrupt changes in the direction of moving parts. All parts move in a uniform manner, and the apparatus as a whole is very simple. It is to be especially noted that, although the recording speed is rather high, neither the film carrier nor the recorders move at this speed, the high speed mentioned being due to the relative motion of recorder and film. This means that

considerable wear is saved in the apparatus.

One can readily see that by employing a suitable number of recorders moving at a proper speed, that photographic sound recording processes requiring a speed of six feet per second may be utilized so that they may be placed on a film that is moving at the standard motion picture speed of one foot per second.

For a more complete understanding of the invention, reference is to be had to the following description and claims taken in connection with the accompanying drawings, in which like characters of reference denote corresponding parts in all thew views, and in which,

Figure 1 is an elevation view showing an electrical reproducing device.

Figure 2 is a cross sectional view on line BC of the rotating film carrier.

Figure 3 is an elevational view of an electrically operated, mechanical sound recorder placed on a radial arm.

Figure 4 is a plan view of a photographic sound recorder placed on a radial arm, also illustrating the detachable nature of the latter.

Figure 5 is a plan view of a device employing mechanical recording, whereby the non-functioning recorder is raised from the film surface at the proper time.

Figure 6 is a side view of a mechanical recording arrangement.

Figure 7 is a view showing the radial arms, stationary cam and contacts for raising recorder from film surface.

Figure 8 is a plan view of the disk attached to the hollow tubes, showing the passage in the valve body above.

Figure 9 is a cross sectional view of the valve body, showing the communicating passages made with the tubes below.

Figure 10 , a and b, are diagrammatic views showing the arrangements of two and three recorders, respectively.

Figure 11 is diagrammatic view showing two recorders playing on each margin of the film.

Figure 12 is an elevational view showing the recorder diaphragm placed at the center of the revolving element, with styli extending as radial arms.

There are many ways of carrying out the invention, and although certain structures will be described in detail, the invention is not limited to them. The film A is passed around the large sprocket wheel 1, contact roll 10 holding it in engagement with sprocket teeth 11, as shown in Figure 1. The film then passes over a smaller sprocket 13, to which is rigidly attached the gear wheel 5. It is obvious that sprocket 13 pulls the film forward. Wheel 5 communicates motion through wheel 4 to wheel 3, which is rigidly attached to shaft 14, which carries the radial arms 2, also rigidly attached to it, and bearing recording or reproducing means at their extremities. Toothed gear wheels 3,4 and 5 are so proportioned that the devices at the extremities of the radial arms move, while in contact with the film surfaces, at a speed which is equal to (when two arms are employed) that of the film, but in the opposite direction. Obviously, the relative speeds of film and recorder passing over it, will be equal to the sum of their individual speeds. Consequently, if the speed of the film is one foot per second, the recording speed is twice this, or two feet per second. One can readily see that if the gearing is so arranged that the recorders move at a speed double that of

the film, and three recorders are used, three records will be impressed, and the recording speed will be three feet per second. Four recorders with a speed of three feet per second would mean a recording speed of four feet per second, and so on.

It is obviously necessary to employ some means whereby only that recorder that is actually impressing its own specific record is in actual operation at any given time, all others being temporarily eliminated from activity. A very satisfactory method of accomplishing this is by the use of electricity, and this will now be described. Other methods will be described later. For thus purpose, the commutator 6, Figure 2, is adjustably attached to the shaft, by means of set screws, or the like in such a position that brush 7 cuts out of circuit the recorder or recorders not functioning, and connecting only the recorder that is functioning. The commutator is shown in this case provided with two segments, one being attached by wire 9 to the device at the extremity of one radial arm, and the other attached by wire 8 to the other recording device. The wires 8 and 9 may pass through shaft 14 which may be provided with suitable conducting passages. In the drawing, the radial arms, shaft, etc., form part of the circuit, in which case only one brush is necessary.

In Figures 1 and 2, the radial arms are provided with simple electrical contacting blades, for the purpose of electrically reproducing aphotographic sound record described in another application about to be filed. The two contact brushes are shown at 15. Figure 3, however, shows a radial arm provided with anelectrically operated, mechanical sound reproducer 17, provided with the stylus 18. The wire 8 and the metal body of the apparatus connects this device with the external reproducing circuit.

However, wires may be used throughout for the circuit connections, and also more than one brush may be used in connection with the commutator. Besides the adjustment of the position of the commutator on the shaft, obviously the brush 7 may be attached to a movable support, as is usual in electrical machinery, whereby it also may be moved to the most favorable position to obtain the best results.

The operation of the apparatus is perfectly simple. A device similar to that shown in Figure 1 may be attached to a camera or projector, and so connected that sprocket 13 is driven at standard motion picture feed, whereupon the recorder or reproducer will move in the opposite direction at the same speed(if but two recorders are used), with the result that the recording or reproducing speed is double that of the film, or about two feet per second.

The large sprocket wheel 1 is not fixed to the shaft 14, but is permitted to revolve freely upon it, and is held in position by the disks 12 and 12', which are fixed firmly to the shaft, and which allow just sufficient play to let wheel 1 revolve freely without vibration. In the drawing, this wheel is shown as being operated by the film as it is drawn through the picture machine. However, a special gearing could be provided to move it directly, if desired.

Strong emphasis is placed on the recording or reproducing apparatus, of which Figure 3 is an illustration of the reproducer. This consists of a stylus operated by a telephone receiver to produce the sound record, and a stylus operating a microphone to reproduce it. This arrangement permits of electrical connections throughout, permitting the use of a commutator, as well as the actual reproduction of the sound record at a distance, such as for instance at a

projection screen. Moreover, the use of microphones or the like in the camera permits the use of special electrical apparatus, not otherwise available, whereby amplification of the sound record may be attained. Such amplifying means are also available in the reproduction of the sound record. The alternate connecting and disconnecting of the recorders is also more effectively accomplished by the employment of an electrical commutator. The set screw 16 rigidly fastens the disk 12 to shaft 14. Recorder 17 is detachable from the radial arm.

Figure 4 shows a photographic recorder 21, consisting of a small tungsten incandescant tubular lamp attached to the extremity of the radial member. It is firmly held in position by the screw 19, while electrical conn ction is made by the wire 8 and conducting metallic body of the arm. The radial arm may be detached from the disk by unscrewing the threaded end 20 out of the corresponding socket. Any type of sound recorder may thus be attached to the radial arm. The term radial member may be construed to mean not only the mechanical device but also a devices that is partly made up of a light beam, which is directed by proper apparatus toward the moving film to chemically alter it. One readily sees that the invention is not concerned with any specific type of sound recording, but with a means of recording sound at a speed that is greater than that of the moving medium upon which the sound is recorded.

If it is desired to record or reproduce without the use of electricity, recourse may be had to the device illustrated in Figures 5,6 and 7. Here the film is wound upon the revolving film carrier as before. The shaft 14 is made hollow. The recorders 22 connect with the hollow shaft by means of the hollow radial members 23, having the flexible

element 24, which may be either a section of rubber tubing or the like, or a sliding joint; this is designed to permit of the recorders 22 being lifted in turn from the surface of the film, by operation of the connections 25 provided with the shoes 26, which coact with the stationary cam 27. The cam is stationary, while the arms revolve. Gear wheel 3 is attached to the shaft 14, which is provided with the passage 34. External connection is made by means of a swivel or other flexible joint, which permits turning but is sufficiently sound tight. The action of spring 28 holds the shoes 26 in firm contact with the cam 27. Wheel 13 moves the film and toothed gear wheel 3,4 and 5 move the radial members in the opposite direction as in Figure 1. It is to be understood that actual contact with the film is only made through part of the circumference of film carrier 1, namely the lower part shown in Figure 6. The radial member lifts the recorder completely away from the film surface when it reaches the upper part of the circumference, as shown in Figure 6; no trouble is occasioned by the ravelling and unravelling of the film at the point where they leave or arrive at the rotating member. The exact contour of the cam shown is not implied in the drawing, as it may be made in many forms other than that shown at 27, Figure 7.

Another modification, whereby the film is in contact with both recorders or reproducers at all times, commutation being made by means of a valve arrangement, is shown in Figures 8 and 9. A disk 30 is rigidly attached to the radial arms 23, and communicates therewith by means of the openings 31. Above this disk is placed the stationary valve body 33 having the passage 32 located directly over the disk 30. Passage 32 communicates with sound tube 34. Tubes 23

are isolated from each other by diaphragm, or partition 38. Moreover, those tubes are rigidly attached to shaft 14 as above described. It can be readily seen that as the radial tubes revolve together with disk 30, openings 31 communicate alternately with passage 32, so that at any given time, but one sound device is recording or reproducing. In other words, only the functioning recorder is in action.

Many other mechanical arrangements are possible, but it is not deemed necessary to illustrate them here. Where the radial members are made up of reciprocating parts, it is best to provide guides as shown at 29. Figure 10, a, illustrates diagrammatically the arrangements of the radial members when three are used, the speed being double that of the film by suitable gearing; the recording speed is thus three times that of the film speed. Figure 10 b illustrates the arrangement diagrammatically when four radial members are employed; their speed is three times that of the film, the recording speed being four times that of the film. Figure 11 is also a diagrammatic view showing a method of using four radial members, two being on each side of the film and co-acting therewith; the recording speed in such case is also four times film speed. Figure 12 illustrates the fact that the recording diaphragm may be located at the center of the revolving film carrier, while the styli extend as radial arms. All of those figures merely illustrate different ways in which the fundamental principles underlying the invention may be carried out. The invention embraces them and many other modifications.

If the photographic method of reproducing is used, the selenium cell or equivalent, can be made in the form of slit arranged in a semicircle corresponding to the form of

the curved film. The effective part of the cell will be thus in the form of a long, narrow slit over which the light recorder on the radial arm passes longitudinally. Consequently, as the light is not stationary, a heat-absorbing means will be unnecessary.

By making the rotating film carrier 1 of very large diameter, the styli would remain in contact with the film for a much longer period. Also the possibility of the commutation of the different reproducers being audibly detected by the audience would be minimized.

Each recorder contacts with the precise portion of the film as regards right or left throughout the length of the film. As the latter is held rigidly in position, the proper sound reproducer finds its corresponding groove with absolute precision.

By making shaft 14 sufficiently long and adding one or more extra arms similar to 2 and 2' and spacing them equidistantly on the shaft, and changing the gearing to rotate them at the proper speed, which is a multiple of the film speed, the sound recording speed is thus increased. The electrical connections and commutator must be also adjusted to correspond. The flexibility of the mechanism is obvious.

In order to offer a firm support to the film while the recorder or reproducer is passing over its surface, an endless belt made of a substance approximating the density of ordinary phonograph record backing material, such as waxed paper, may be arranged so as to pass around the contact roll 10 and sprocket 13. This belt may be provided with a slack adjuster consisting, for instance of a weighted pulley.

Wheels 3,4 and 5 are supported on any suitable frame work. Power is preferably applied to 5 or 13, so as to move the film at standard motion picture speed. The film, however, may be simply pulled through the apparatus by other sprocket wheels.

Laterally undulating sound recording has been very successful commercially, and as there is room for many such record grooves on the margin of a moving picture film, the invention offers a means of placing several such records there and utilizing them to reproduce sounds. Moreover, by this means a recording speed is available that is in excess of that used in commercial sound recording.

An advantage of electrical commutation is that a record can come into contact with the film for a time before it is actually brought into electrical connection.

In the appended claims wherever the word record is used, it is intended to broadly cover both recorder and reproducer; recording likewise covers reproducing.

Having thus described my invention, I claim as new and desire to secure by Letters Patent,

1.-The process of sound recording, consisting of moving film and styli in opposite directions at a recording speed that is greater than film speed, and permitting but one stylus to function at a time.

2.-A combination, consisting of means for moving a film and contacting styli in opposite directions at a speed of recording which is greater than film speed, and means for permitting bat one recorder to function at a time.

3.-A combination consisting of means for moving a film and contacting styli in opposite directions at a recording speed greater than film speed, and electrical means for permitting but one recorder to function at a time.

4.-A combination consisting of oppositely moving film carrier and radial members; said carrier and members being moved in opposite directions while in contact by suitable gearing, and at a recording speed greater than film speed; a commutating mechanism which permits but one recorder to function at a time.

5.-A combination, consisting of film carrier and radial members provided with means for connecting but one recorder to external circuit at a time; mechanical means for moving said film and radial members in opposite directions to obtain a recording speed greater than film speed.

6.-A combination consisting of a film carrier and revolving shaft bearing sound recorders, and mechanical means for moving said film carriers and recorders in opposite directions; electrical means for connecting but one recorder to external circuit at a time.

7.-A combination, consisting of a film carrier, a shaft attached to sound recorders; means for moving said film and recorders in opposite directions to obtain a recording speed greater than film speed; means for connecting but one recorder to external circuit at a time.

8.-A combination, consisting of a film carrier, a shaft bearing radial sound recorders; suitable gearing for moving film and recorders in opposite directions to obtain a recording speed that is greater than film speed; means for connecting but one recorder to external circuit at a time.

9.-A combination, consisting of a film carrier and radial members and suitable sprocket and gear wheels for moving film and radial members in op posite directions to obtain a recording speed that is greater than film speed; means for connecting but one recorder at a time to the external circuit.

10.-A combination consisting of film carrier, a shaft rigidly attached to radial arms bearing recorders; suitable gearing for moving film and radial members in opposite directions to obtain a recording speed that is greater than film speed; shaft and members being provided with commutator and electrical circuit to connect but one recorder to external circuit at a time.

11.-A combination consisting of film carrier and shaft bearing radial sound recorders; mechanical means, consisting of sprocket and gear wheels for moving said film and radial members in opposite directions to obtain a recording speed greater than film speed; means, consisting of commutator and electrical circuit for connecting but one recorder to external circuit.

12.-A combination consisting of a film carrier and shaft rigidly attached to radial members bearing sound recorders; mechanical means, consisting of sprocket and gear wheels for moving film and radial members in opposite directions to obtain a recording speed greater than film speed; means for connecting but one recorder to external circuit at a time.

13.-A combination consisting of a film carrier, a shaft rigidly attached to radial members bearing sound recorders, said shaft and members being provided with means, consisting of commutator and electrical circuit for connecting but one recorder to external circuit at a time; mechanical means consisting of sprocket and gear wheels for moving said filmand radial members in opposite directions to obtain a recording speed that is greater than film speed.

14.-A combination consiting of a film carrier and radial arms bearing reporders; means for moving film and recorders in opposite directions to obtain a recording speed greater than film speed; means to lift the non-functioning recorders from film surface.

15.-A combination consisting of a film carrier, and radial members rigidly connected to a hollow shaft; means for moving film and recorders in opposite directions to obtain a recording speed that is greater than film speed; means mechanical means for lifting non-function recorders from film surface.

16.-A combination consisting of a film carrier and

16

andcradial arms carrying sound tubes and recorders connected to hollow shaft to form a sound passage;means for moving film and recorders in opposite directions to obtain a recording speed that is greater than film speed; mechanical means for lifting non functioning recorders from film surface.

17.-A combination consisting of a film carrier and radial arms carrying sound tubes and recorders connected to hollow shaft to form a sound passage; mechanical means for lifting non-functioning recorders from film surface; suitable shoes and rods operated by stationary cam; suitable gearing for moving film and recorders in opposite direction to obtain a recording speed greater than film speed.

18.-A combination consisting of a film carrier and radial members rigidly connected to revolving shaft; means consisting of gear wheels for moving film and recorders in opposite directions; mechanical means for lifting non-function-recorders from film surface.

19.-A combination consisting of a film carrier and radial arms carrying recorders rigidly connected to hollow shaft; means for moving film and recorders in opposite directions to obtain a recording speed that is greater than film speed; means consisting of shoes and rods operated by a cam to lift non-function recorders from film surface.

20.-A combination consisting of a film carrier and radial arms provided with hollow sound tubes connecting with recorders, said tubes having flexible members and being connected to a hollow shaft to form a sound passage; means for moving film and recorders in opposite directions to obtain a recording speed that is greater than film speed; means for lifting non-functioning recorders from film surface.

21.-A combination consisting of film carrier and radial members rigidly connected to a hollow shaft; means for moving film and recorders in opposite directions to obtain a recording speed that is greater than film speed; said members provided with suitable means for lifting non-function record-

from film surface.

22.-A combination consisting of film carrier and radials members provided with hollow sound tubes rigidly connected to a hollow shaft to form a sound passage; means consisting of sprocket and gear wheels for moving film and recorders in opposite directions to obtain a recordingspeed that is greater than film speed; means for lifting non-functioning recorders from film surface.

23.-A combination consisting of a film carrier and radial arms provided with sound tubes having flexible members rigidly connected to a hollow shaft to form a sound passage with recorders on extremities of said arms; means consisting of suitable sprocket and gear wheels for moving film and recorders in opposite directions to obtain a recording speed that is greater than film speed; means operated by a cam for lifting non-functioning recorders from film surface.

24.-A combination consisting of a film carrier and hollow radial tubes bearing recorders; means for moving film and recorders in opposite directions to obtain recording speed greater than film speed; means whereby only the functioning recorder communicates with external sound tube.

25.-A combination consisting of a film carrier and hollow radial tubes bearing sound recorders rotated by shaft; suitable gearing for moving film and recorders oppositely to obtain a recording speed in excess of film speed; a stationary valve which permits only the functioning recorder to connect with external sound tube.

26.-A combination consisting of a film carrier and hollow radial tubes bearing recorders; means for moving film and recorders in opposite directions to obtain a recording speed greaternthan film speed; a valve connecting with said tubes which permits only the functioning recorder to communicate with external sound tube.

27.-A combination consisting of a film carrier and hollow radial tubes bearing sound recorders; suitable sprock and gear wheels to move said film and recorders oppositely to obtain a recording speed in excess of film speed; A stationary valve which permits only the functioning recorder to communicate with external sound tube.

28.-A combination consisting of a film carrier and hollow radial tubes bearing recorders, said tubes being attached to and rotated by shaft; means consisting of suitable gearing for moving film and recorders oppositely to obtain a recording speed that is in excess of film speed; a valve which permits only the functioning recorder to communicate with external tube.

29.-A combination consisting of a film carrier and radial tubes attached to shaft; sprocket and gear wheels for moving film and recorders oppositely to obtain a recording speed in excess of film speed; a valve connecting with said members whereby only the function recorder is connected to the external tube.

30.-A combination consisting of a film carrier and radial tubes bearing recorders; means consisting of combined sprocket and gear wheels for moving film and recorders in opposite directions to obtain a recording speed that is in excess of film speed; a stationary valve consisting of a revolving disk attached, and having openings connecting with said arms whereby only the functioning recorder communicates with external tube.

31.-A combination consisting of a film carrier and radial tubes attached to shaft and rotated thereby; gear wheels to move film and recorders oppositely to obtain a recording speed greater than film speed; a valve consisting of revolving disk attached to tubes, whereby only the functioning recorder communicates with external sound tube.

32.-A combination consisting of a film carrier and radial tubes bearing recorders, normally incommunicable, said members attached to and rotated by shaft; means consisting of sprocket and gear wheels whereby the film and recorders are moved in opposite directions to obtain a recording speed that is in excess of film speed; A stationary valve consisting of a revolving disk attached to said tubes and having openings therewith, whereby only the functioning recorder communicates with external sound tube.

33.-A recorder concentrically revolving upon a shaft with styli extending radially to alternately engage with film; means for moving film and styli oppositely to obtain a recording speed in excess of film speed;

34.-A recorder concentrically revolving upon a shaft with styli extending radially from the diaphragm thereof to alternately engage with film; means for moving film and styli oppositely to obtain a recording speed in excess of film speed; means for connecting but the functioning recorder.

38.-A moving picture film provided with a plurality of sound records longitudinally placed thereon, the recording speeds of the sound records being greater than the speed of the film.

36.- A moving picture film provided with a plurality of longitudinal sound records on one or both margins, the recording speed of the sound records being greater than that of the film.

Clarence J. Dawley

Invented Dec. 26, 1919

Fig. 1

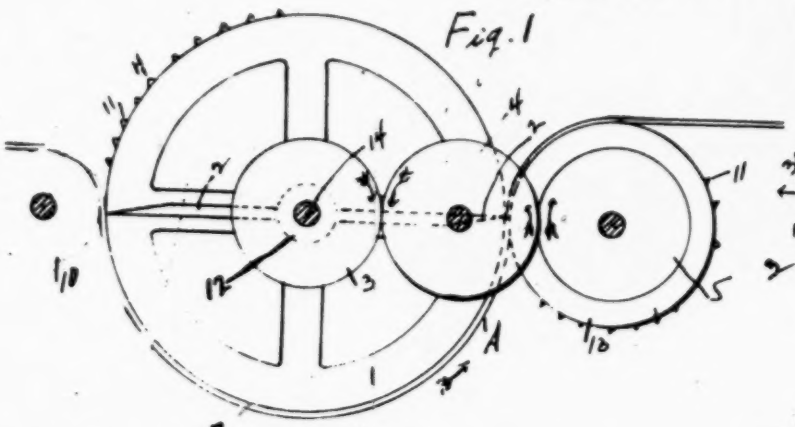


Fig. 5

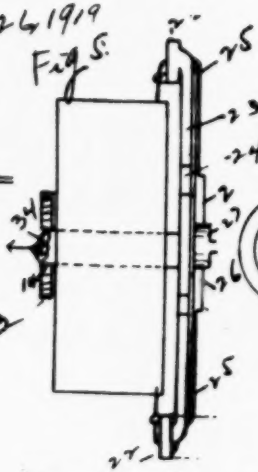
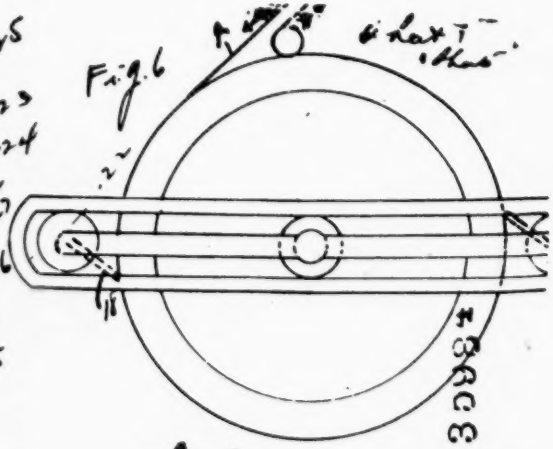


Fig. 6



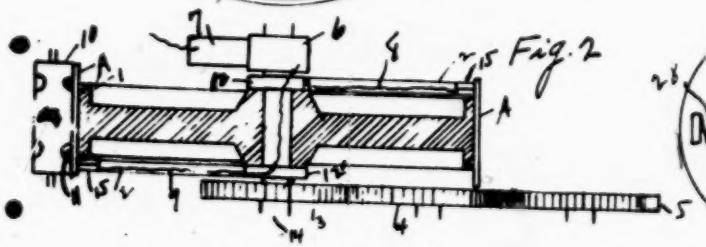


Fig. 2

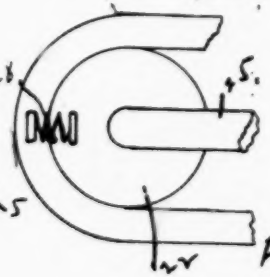
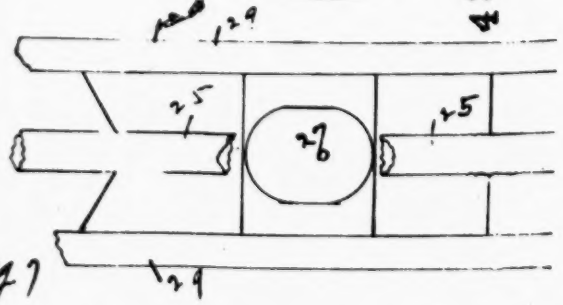


Fig. 7



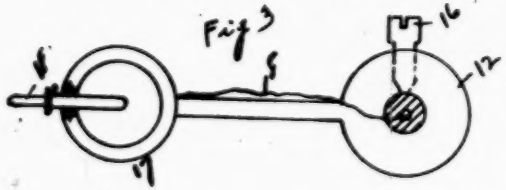


Fig. 3

Fig. 4

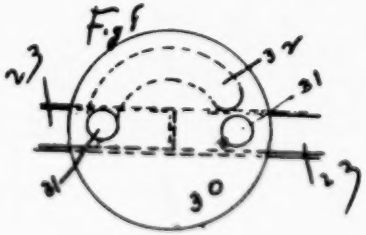


Fig. 8

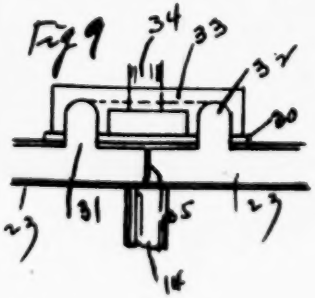


Fig. 9

1587

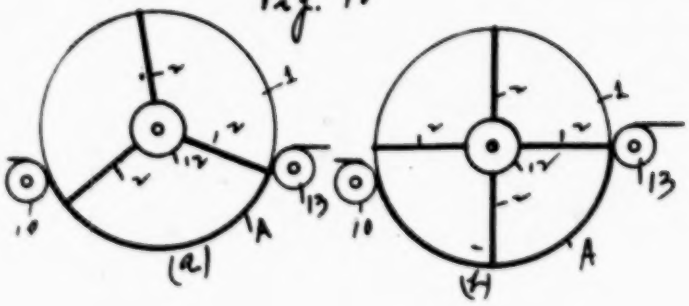
1538

Drawing to correspond to three sheets.

Granted Dec 26, 1919.

Sheet 1 of Three sheets.

Fig. 11



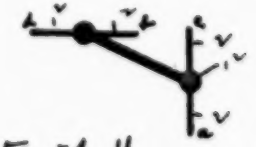
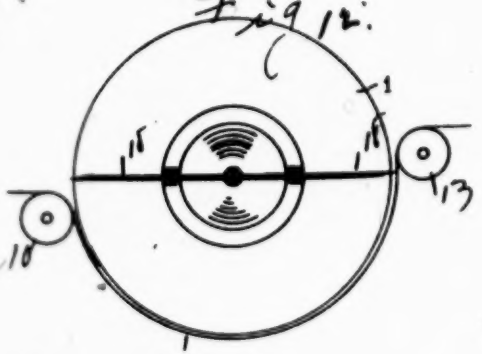
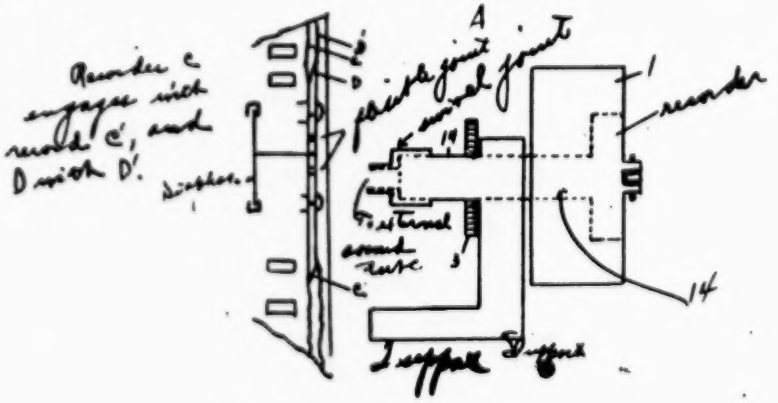


Fig. 11

Fig 12.





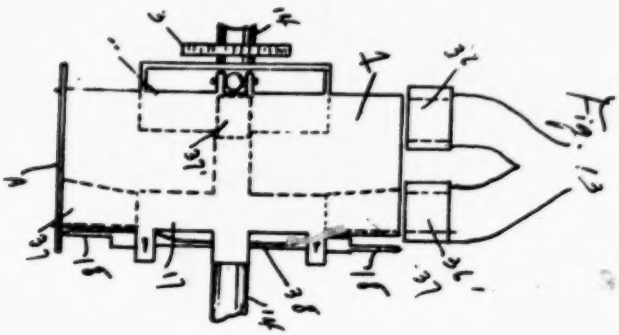


Fig. 13

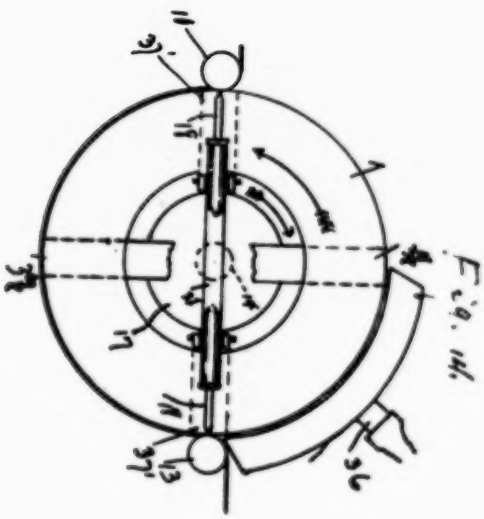


Fig. 14

Drawings will be made to
correspond to all three sketches.

DEFENDANTS' EXHIBIT NO. 96.

Application as Originally Filed of Kunz Patent No. 1,381,474, Granted June 14, 1921.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 97.

Application as Originally Filed of Compton Patent No. 1,567,424, Granted December 29, 1925.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 98.

File History and Contents of German Patent No. 387,058, to Vogt, Massolle and Engl, With Translation.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 99.

Nullity Proceedings in German Patent Office, Entitled "Herman Greiff v. Tri-Ergon Holding A. G., et al, and Electrical Research Products, Inc., v. Tri-Ergon Holding A. G., et al," Relating to German Patent No. 387,058, With Translations.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 100.

File History of German Patent No. 389,317 to Massolle, Vogt and Engl, With Translation.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 101.

Nullity Proceedings in German Patent Office Re German Patent No. 389,317, to Massolle, Vogt and Engl, With Translation.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 102.

File History and Contents of German Patent No. 389,318, to Massolle, Vogt and Engl, With Translation.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 103.

Nullity Proceedings in German Patent Office Re German Patent No. 389,318, to Massolle, Vogt and Engl, With Translation.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 104.

File History of German Patent No. 389,319, to Massolle, Vogt and Engl, With Translation.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 105.

Nullity Proceedings in German Patent Office With Respect to German Patent No. 389,319, to Massolle, Vogt and Engl, With Translation.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 106.

DEUTSCHES REICH

AUSGEGEBEN
AM 27. DEZEMBER 1923

U. S. DISTRICT COURT
M. D. FL
DEFT. EX. 106

REICHSPATENTAMT

PATENTSCHRIFT

№ 387058 —

KLASSE 42g GRUPPE 7

(V 15574 IX/42g)

Hans Vogt in Berlin-Wilmersdorf,
Joseph Massolle und Dr. Josef Engl in Berlin-Grunewald.

Einrichtung für Phonographen zum gleichförmigen Antrieb des linearen Phonogrammträgers.

Patentiert im Deutschen Reiche vom 23. Mai 1920 ab.

Bei phonographischen Darbietungen hängt Qualität und Originaltreue der reproduzierten Klänge und Laute von der Güte der Aufzeichnung und von der Geschwindigkeit ab, mit der sich der Phonogrammträger an der Steuerstelle (Magnet, Lichtlinie, Schalldosenstift u. ä.) vorbeibewegt. Den zu erfüllenden Bedingungen, daß erstens die mittlere Aufnahme- und Wiedergabegeschwindigkeit einander gleich sein müssen, und zweitens die Vorbeibewegung des Phonogrammträgers an der Steuerstelle vollkommen kontinuierlich erfolgen muß, entsprechen die bekannten Phonographen, deren Phonogrammträger aus Bändern, Drähten u. dgl. bestehen, nicht. Es sind weder Einrichtungen bekannt, die eine genaue Kontrolle und Regulierung der Phonogrammträgergeschwindigkeit unmittelbar an der Steuerstelle gestatten, noch gewährleisten diese Phonographen eine absolute augenblickliche Bewegungskonstanz. Denn Versuche haben gezeigt, daß der Tonträger die für ihn fast immer einen Reibungswiderstand darstellende Steuerstelle meist nicht kontinuierlich, sondern ruckweise passiert. Besonders tritt diese Störerscheinung zutage, wenn der Tonträger beispielsweise als perforiertes Filmband ausgebildet ist und, synchron mit einem Bildfilm ablaufend, für die Zwecke des sprechenden Kinematographen Verwendung findet. Hier können außer der schon erwähnten, von der Reibung abhängigen Unregelmäßigkeit die intermittierenden Bewegungen des Bildbandes, der Einfluß der Zackenrollen und der Riemenverbindungsstellen eine derartige Diskontinuität an der Steuerstelle des Tonbandes hervorrufen, daß genußreiches Hören zur Unmöglichkeit wird.

Die Erfindung beseitigt diese Nachteile. Sie gewährleistet unmittelbar an der Steuerstelle sowohl eine regelbare mittlere als auch eine augenblickliche, absolut konstante Fortbewegungsschnelligkeit des Phonogrammträgers. Dies wird erreicht, indem die Aufzeichnungs- oder Steuerstelle des an Masse geringen längsbewegten Tonträgers so mit einer rotierenden weit größeren Masse gekuppelt wird, daß die, keinen schnellen zeitlichen Schwankungen unterworfene Umdrehungszahl der letzteren bestimmend für die Längsgeschwindigkeit des Tonbandes ist.

In Abb. 1 ist die Erfindung im Prinzip beispielsweise für den Wiedergabeteil eines optischen Phonographen veranschaulicht. *f* ist der Tonfilm; der ein von dem optischen System *o* kommendes Lichtbündel steuert, das dann die lichtelektrische Zelle *z* verschieden stark (im akustischen Rhythmus) belichtet. Die Führungsleisten *l*, *l* halten den Tonfilm, der von einer nicht gezeichneten Rolle angetrieben wird, genau in der Brennlinie bzw. tragen einen schmalen Spalt. Kurz vor oder nach dieser Führung passiert der Film zwei mit Druck gegeneinander anliegende Rol-

len r_1, r_2, deren eine mit einer Schwungmasse m verbunden ist. Die den Gleichlauf bewirkenden Rollen können auch unmittelbar an der Steuerstelle zur Führung des Tonbandes benutzt werden. Gegebenenfalls könnten zwei solcher Gleichlauferzeuger vorhanden und so miteinander mittels Riemen u. dgl. verbunden sein, daß eine kleine Umdrehungsdifferenz den Film, das Stahlband o. dgl. an der Steuerstrecke während des Laufens andauernd gespannt hält.

Abb. 2 zeigt ein derartiges Ausführungsbeispiel. Der Film f wird von zwei Rollenpaaren r_1, r_2 und r_3, r_4 angetrieben. r_3, r_4 besitzen eine höhere Umfangsgeschwindigkeit wie r_1, r_2. Erzielt wird dies beispielsweise durch die Antriebsscheiben s_1, s_2, von denen s_2 einen kleineren Durchmesser besitzt. Die Achse der Rolle r_2 bzw. m ist außerdem mit einem nicht gezeichneten Umdrehungszähler und Umdrehungsregler verbunden, die durch Einwirken auf den Antriebsmotor die mittlere Wiedergabegeschwindigkeit einhalten. Daß eine derartig geregelte Wiedergabe nur Sinn hat, wenn man auch bei der Aufnahme dieselben Maßnahmen anwendet, ist selbstverständlich.

Patent-Ansprüche:

1. Einrichtung für Phonographen zum gleichförmigen Antrieb des linearen Phonogrammträgers, insbesondere für die Zwecke des sprechenden Films, dadurch gekennzeichnet, daß zwecks Erzielung immer konstanter und regelbarer mittlerer Längsgeschwindigkeit an der Steuerstelle der Phonogrammträger mit einer rotierenden Schwungmasse gekuppelt ist.

2. Ausführungsform nach Anspruch 1, dadurch gekennzeichnet, daß Geschwindigkeitszähler und Geschwindigkeitsregler Anwendung finden.

3. Ausführungsform nach Anspruch 1 und 2, dadurch gekennzeichnet, daß zwei Rotationssysteme den Phonogrammträger steuern.

4. Ausführungsform nach Anspruch 3, dadurch gekennzeichnet, daß die Filmantriebsrollen der Rotationssysteme verschiedene Umfangsgeschwindigkeit besitzen.

5. Ausführungsform nach Anspruch 1, dadurch gekennzeichnet, daß als Kupplung zwischen Phonogrammträger und Rotationskörper eine Reibungskupplung dient.

Abb. 1.

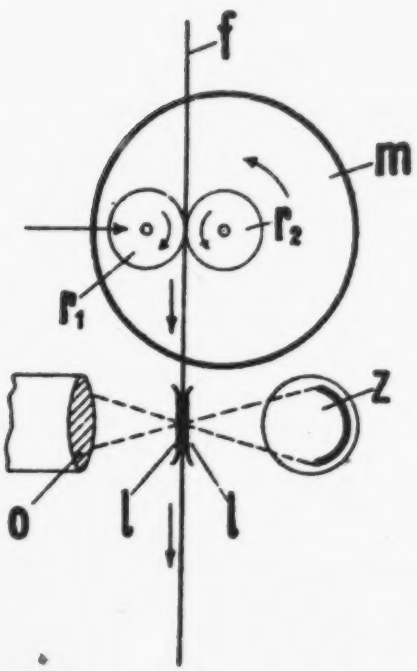
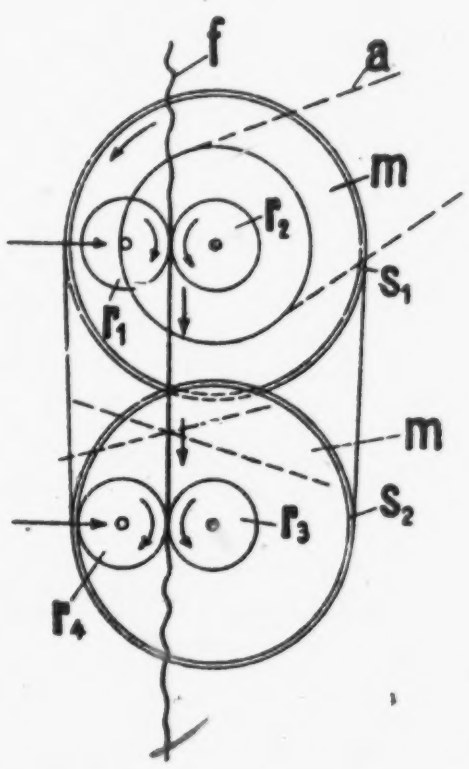


Abb. 2.



Translation.

GERMAN EMPIRE.

Issued on December 27, 1923.

GERMAN PATENT OFFICE.
LETTERS PATENT.
No. 387,058.

Class 42g Group 7.

(V 15574 IX/42g).

Hans Vogt in Berlin-Wilmersdorf, Joseph Massolle and Dr. Josef Engl in Berlin-Grunewald. Device for phonograph for uniform drive of the linear phonogram carrier. Patented in Germany as from May 23rd, 1920.

In connection with phonographic reproductions the quality and the faithfulness of the reproduced music and sounds compared to the original depends on the quality of the recording and on the speed at which the phonogram carrier passes the control place (magnet, light line, sound box stylus or needle, etc.). The requirements to be complied with in this connection, namely, that first of all the average recording and reproduction speed must be the same and that secondly the moving of the phonogram carrier past the control place must take place in an absolutely continuous manner, are not complied with by the known phonographs, the phonogram carriers of which consist of bands, wires or the like. No devices have become known which make possible an exact control and regulation of the speed of the phonogram carrier directly at the control place, nor do these phonographs insure an absolute instantaneous moving constancy, for experiments have shown that the sound carrier experiences

a frictional resistance at the control place and in most cases passes it not continuously but in a jerky manner. This interfering or disturbance phenomenon occurs especially if the sound carrier is, for instance, in the form of a perforated film and, running off synchronously with a picture film, is used to produce talking motion pictures. In addition to the above mentioned irregularities due to friction, the intermittent movement of the picture film, the influence of the sprockets, and of the belt joints can bring about such discontinuity at the control place of the sound band that enjoyable rendition becomes impossible.

The invention eliminates these disadvantages. It assures directly at the control place, both controllable average and also an instantaneous, absolutely constant propulsion velocity of the phonogram carrier. This is attained by coupling the recording or control place of the sound carrier (which is being moved longitudinally and which is of small mass) with a rotating and much larger mass, in such a manner that the number of revolutions of the latter, which is not subject to any rapid fluctuations, determines the longitudinal speed of the sound band. In Fig. 1, the invention is shown in principle, for instance, for the reproduction part of an optical phonograph. *f* is the sound film which controls a bundle of rays coming from the optical system *o*, which bundle of rays in turn illuminates with varying intensities the photo-electric cell *z*, in acoustic rhythm. The guide bars *l,l* hold the sound film, which is driven by one roller, not shown in the drawing, exactly in the focal line, or the guide bars are provided with a narrow slit. Shortly ahead of or after this guiding, the film passes two rollers r_1, r_2, resting under pressure against each other, one of which is connected with a centrifugal mass *m*. The rollers bringing about the uniform speed can also be used directly at the control place for the guiding of the

sound band. If necessary two such devices for producing a uniform run can be provided and connected with each other by means of belts or the like, in such a manner that a slight difference in rotation keeps the film, the steel band or the like, taut at the control section (stretch) during the running.

Fig. 2 shows such an embodiment. The film f is driven by two pairs of rollers r_1, r_2 and r_3, r_4. r_3, r_4 have a higher circumferential speed than r_1, r_2. This is obtained, for instance, by the driving discs s_1, s_2, of which s_2 has a smaller diameter. The axis of the roller r_2 or m, respectively, is furthermore connected with a revolution counter and speed governor, not shown in the drawing, which, by acting upon the driving motor, maintain the average reproduction speed. It is obvious that a reproduction governed in this manner is then only useful if during the recording the same measures are also applied.

PATENT CLAIMS:

1. Device for phonographs for the uniform drive of the linear phonogram carrier especially for purposes of the talking film, having the distinctive feature that in order to obtain an always constant and controllable mean longitudinal speed at the control place the phonogram carrier is coupled with a rotating centrifugal mass.

2. Manner of execution in accordance with Claim 1, having the distinctive feature that speedometers and speed governors are used.

3. Manner of execution in accordance with Claims 1 and 2, having the distinctive feature that two rotation systems control the phonogram carrier.

4. Manner of execution in accordance with Claim 3, having the distinctive feature that the film driving

rollers of the rotation systems operate at different circumferential speed.

5. Manner of execution in accordance with Claim 1, having the distinctive feature that the coupling between the phonogram carrier and the rotation body is a friction coupling.

DEFENDANTS' EXHIBIT NO. 107.

DEUTSCHES REICH

AUSGEGEBEN
AM 5. FEBRUAR 1924

REICHSPATENTAMT

PATENTSCHRIFT

— № 389317 —

KLASSE 42g GRUPPE 7

(V 17149 IX/42g)

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U. S. DISTRICT COURT
M. D. PENN.
DEFT. EX. 107

Joseph Massolle in Berlin-Grunewald, Hans Vogt in Berlin-Wilmersdorf und Dr. Josef Engl in Berlin-Grunewald.

Einrichtung für Phonographen mit linearem Phonogrammträger, insbesondere für die Zwecke des sprechenden Films.

Zusatz zum Patent 387058.

Patentiert im Deutschen Reiche vom 24. Januar 1922 ab.

Längste Dauer: 22. Mai 1936.

Gegenstand des Hauptpatentes 387058 ist eine Einrichtung, nach welcher der Tonfilm bei seiner Fortschaltung mit einer Schwungmasse gekuppelt ist.

Bei der geringen Umdrehungszahl der Antriebswelle des Tonfilmes und starrem Antrieb genügt die Umfangsgeschwindigkeit von Schwungmassen, die sich praktisch noch verwenden lassen, jedoch nicht zur Kompensation der Geschwindigkeitsschwankungen.

Erfindungsgemäß erfolgt deshalb der Antrieb der Schwungmassenachse mittels einer elastischen Kupplung, beispielsweise einer Feder. Diese kann sehr weich sein, da sie bei gleichbleibender Geschwindigkeit nur die Reibungsverluste des zu treibenden Teiles zu überwinden hat. Da beim An- und Auslaufen des Triebwerkes die Trägheit der Schwungmasse überwunden werden muß, ist es vorteilhaft, das Spiel der Feder beiderseits durch einen festen Anschlag zu begrenzen.

An sich ist die Verbindung zweier Achsen durch ein elastisches Glied bekannt, und zwar für Sprechmaschinen. Jedoch genügt eine der-

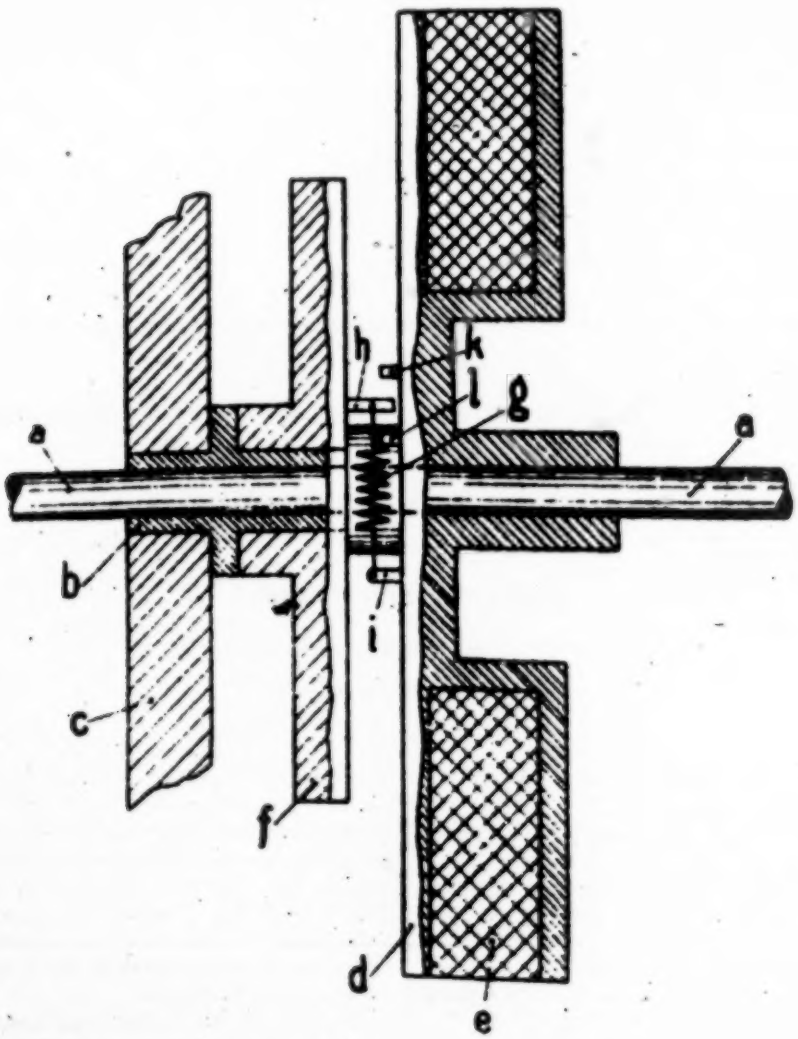
artige Kupplung allein nicht, da, wenn die Übertragung von stoßweisen Geschwindigkeitsschwankungen der treibenden Achse auf die getriebene Achse vermieden werden soll, letztere einen Energiespeicher besitzen muß, der die Stöße ausgleicht, indem er bei Zunahme der Antriebsenergie diese aufnimmt, bei Abnahme der Antriebsenergie Energie an die getriebene Achse abgibt. Dieser Energiespeicher ist im vorliegenden Falle die mit der getriebenen Achse verbundene Schwungmasse.

Die Abbildung stellt ein Ausführungsbeispiel dar. Die Tonfilmantriebsachse *a*, gelagert in der in die Lagerwand *c* eingesetzten Lagerbüchse *b*, ist fest mit dem Schwungmassenrade *d* verbunden, welches zur Erhöhung der Schwungmasse mit einer besonders schweren Füllung *e* (etwa Blei) ausgefüllt sein kann. Auf der Lagerbuchse *b* läuft eine lose Scheibe *f*, die von der treibenden, nicht gezeichneten Achse angetrieben wird. Die Verbindung zwischen *f* und *a* erfolgt durch die Feder *g*, die zwischen zwei Mitnehmern *h* und *i*, von denen *h* an *f* und *i* an *d* befestigt ist, eingesetzt ist. Indem *f* angetrieben wird, spannt sich die Feder und treibt dadurch über *d* die Achse *a* an. *k* und *l* sind Anschläge für *h*, damit beim Ein- und Ausschalten die Feder nicht beschädigt wird.

Patent-Ansprüche:

1. Einrichtung für Phonographen mit linearem Phonogrammträger, insbesondere für die Zwecke des sprechenden Films, nach Patent 387058, dadurch gekennzeichnet, daß der Antrieb der Schwungmassenachse mittels einer elastischen Kupplung erfolgt.

2. Einrichtung nach Anspruch 1, dadurch gekennzeichnet, daß das Spiel der eine Feder bildenden Kupplung durch feste Anschläge begrenzt ist.



Translation.

Reich of Germany.
National Patent Office.

Issued:
5th. February, 1924.

PATENT SPECIFICATION NO. 389,317.

Class 42g, Group 7.

Appliance for Phonographs with a Linear Phonogram Carrier More Particularly for the Purposes of Talking Films.

Addition to Patent 387,058.

Patent in Force in Germany from January 24th., 1922.
Longest Duration: May 22, 1938.

Joseph Massolle in Berlin-Grunewald, Hans Vogt in Berlin-Wilmersdorf and Dr. Josef Engl in Berlin-Grunewald.

The object of the main patent 387,058 is an appliance according to which the talking film is coupled with a flywheel mass in its feed movement.

At the low number of revolutions of the driving shaft for the phonofilm and with a rigid drive, the circumferential velocity of the flywheel masses allowing of being employed for practical purposes will not, however, be sufficient to compensate the fluctuations of speed.

Therefore, according to the invention, the drive of the flywheel spindle is obtained by means of a flexible connection, for instance, of a spring. The spring may be very soft as it only has to overcome the frictional losses of the driven part as long as the speed remains uniform. As on starting and stopping the driving gear the inertia of the flywheel mass has to be overcome, it is advantageous to limit the play of the spring by firm stops in both directions.

The connection of the two axes by means of an elastic link is known as such, viz. for talking machines. Such a coupling alone, however, will not suffice because if it is desired to avoid the transmission of jerky fluctuations of speed of the driving shaft to the driven axis, the latter will have to be provided with an accumulator of energy to equalise the impulses by taking up the driving energy when same increases, and by transferring energy to the driven axis when the driving energy decreases. In the above case this energy-accumulator is represented by the centrifugal mass connected with the driven axis.

The illustration depicts a practical application. The driving shaft *a* for the sound film supported in bearing bushing *b* which in turn is fitted in the supporting wall *c* is rigidly connected with the flywheel *d*, which, in order to increase the centrifugal mass, may be filled with a heavy filling *e* (e. g. with lead). On the bearing bush *b* rotates a loose disc *f*, driven by the driving axis, not shown. The connection between *f* and *a* is ensured by means of a spring *g*, interposed between two carriers *h* and *i*, whereof *h* is fixed to *f*, and *i* to *d*. As *f* is driven, the spring will be tensioned and thereby drives the axis *a* by means of *d*. *k* and *l* are stops for *h* to prevent the spring being damaged when starting or stopping.

Claims.

1. Appliance for phonographs with linear phonogram-carrier, more particularly for the purposes of talking films, according to Patent 387,058, characterised in this that the drive of the flywheel axis is ensured by means of a flexible coupling.

2. Appliance as per claim 1, characterised in this that the movement allowed by the coupling is limited by fixed stops.

DEFENDANTS' EXHIBIT NO. 108.

U. S. DISTRICT COURT
M. D. FL
DEFT. EX. 108

DEUTSCHES REICH

AUSGEGEBEN
AM 5. FEBRUAR 1924

REICHSPATENTAMT

PATENTSCHRIFT

№ 389318

KLASSE 42g GRUPPE 17

(V 16360 IX/42g)

Joseph Massolle in Berlin-Grunewald, Hans Vogt in Berlin-Wilmersdorf und Dr. Josef Engl in Berlin-Grunewald.

Einrichtung für Phonographen mit linearem Phonogrammträger.

Zusatz zum Patent 387058.

Patentiert im Deutschen Reiche vom 25. März 1921 ab.

Längste Dauer: 22. Mai 1938.

Die Aufzeichnung und Wiedergabe von Schallwellen unter Benutzung von linearen Phonogrammträgern, wie Filmbändern, Stahldrähten o. dgl., ist bekanntlich nur dann einwandfrei möglich, wenn die Geschwindigkeit des Tonträgers bei Aufnahme und Wiedergabe die gleiche ist und in beiden Fällen keinerlei Geschwindigkeitsschwankungen auftreten. Dies ist besonders wesentlich bei musikalischen Vorgängen, die bekanntlich sehr empfindlich gegen die geringsten Geschwindigkeitsschwankungen sind.

Nach dem Gegenstand des Hauptpatents 387058 wird für den Phonogrammträger an der Aufnahme- bzw. Steuerstelle diese konstante Geschwindigkeit dadurch gewährleistet, daß der Phonogrammträger mit einer rotierenden Schwungmasse gekuppelt ist.

Erfindungsgemäß wird die Gleichlaufeinrichtung derart ausgeführt, daß sich die Aufnahme- bzw. Steuerstelle des Phonogrammträgers zwischen den beiden mit Schwungmasse versehenen Rollen befindet. Das Filmstück läuft infolgedessen gespannt zwischen den beiden Rollen, so daß die Gleichmäßigkeit seiner Bewegung erhöht wird. Die Unregelmäßigkeiten, die oft durch die Zähne oder die zu mechanischen Schwingungen neigenden Filmstrecken verursacht werden, können dadurch vermieden werden, daß die Aufnahme- bzw. Steuerstelle des Phonogrammträgers auf dem Umfang einer mit Schwungmasse versehenen Rolle vorgesehen wird.

Beispielsweise Ausführungsformen der Erfindung sind in den Abbildungen dargestellt. Der Phonogrammträger, der bei diesen Ausführungsformen ein Filmband ist, bewegt sich über die zweckmäßig durch Zahn- oder Riementrieb gekuppelten Rollen r_1, r_2, von denen am besten die direkt vom Motor angetriebene Rolle r_2 mit Zähnen versehen ist. Beide Rollen sind mit Schwungmassen m_1, m_2 starr verbunden, die dem zwischen ihnen laufenden, gespannten Filmstück f die erforderliche Gleichmäßigkeit in seiner Bewegung geben. Zwischen den Rollen r_1, r_2 befindet sich zweckmäßig in einer Hülse h das lichtelektrische empfindliche Organ s, das von einem aus o austretenden und den Film f passierenden Lichtstrahl beeinflußt wird. Die Rollen dr_1, dr_2 drücken den Film an die Transportrolle r_2 an.

Eine andere Ausführung der Erfindung, wobei die kleinen Unregelmäßigkeiten, die häufig die Zähne oder die beispielsweise leicht zu mechanischen Schwingungen neigenden Filmstrecken zwischen r_1 und r_2 verursachen, vermieden werden, ist in Abb. 2 dargestellt.

Der Film f wird durch die Rolle r_1 der

Steuerstelle *s* zu- und durch die Rolle r_2 von der Steuerstelle weggeführt. Zwischen diesen Transportrollen wird der Film über den Umfang einer größeren Rolle *R* geleitet, auf der er durch Adhäsion auch während der Drehbewegung fest aufliegt. Da die Rolle mit der Schwungmasse *m* starr verbunden ist bzw. selbst als Schwungmasse ausgebildet sein kann, bewegt sich der Film ebenso gleichmäßig weiter wie die Oberfläche der Rolle *R*. Zum Andrücken des Films an die Rolle *R* sowie zum Ausgleich von Bewegungsunregelmäßigkeiten dienen die federnd gelagerten Rollen dr_1, dr_2. Die zur Belichtung bzw. Durchleuchtung des Films erforderlichen Lichtstrahlen werden mittels des Objektivs *o* in Form einer schmalen Linie auf den Film geworfen. Bei der Wiedergabe treten die Lichtstrahlen durch das Filmband hindurch und fallen auf die z. B. in ihrem Innern angebrachte Photozelle *z*. Zu diesem Zweck ist entweder die Rolle teilweise durchsichtig (aus Glas), oder der die Tonzeichen tragende Teil des Films ragt über die undurchsichtigen Teile der Rolle hinweg.

Patent-Anspruch:

Einrichtung für Phonographen mit linearem Phonogrammträger nach Patent 387058, dadurch gekennzeichnet, daß die Aufnahme- bzw. Steuerstelle (*s*) des Phonogrammträgers (*f*) zwischen den beiden mit je einer Schwungmasse (m_1 bzw. m_2) versehenen Rollen (r_1, r_2) oder bei Verwendung einer mit Schwungmasse (*m*) versehenen Rolle (*R*) auf deren Umfang vorgesehen ist.

Abb. 1.

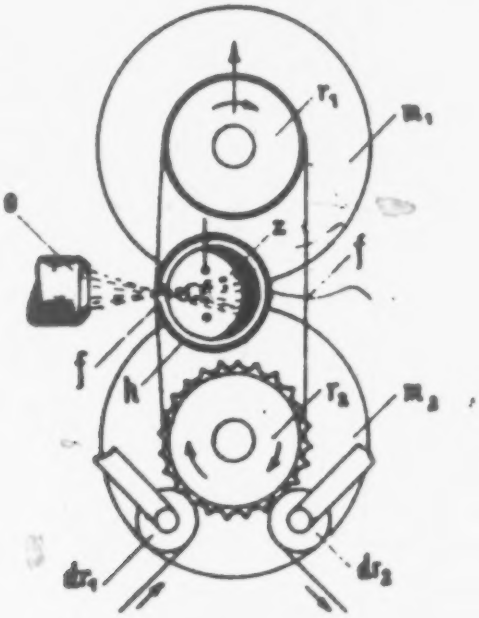
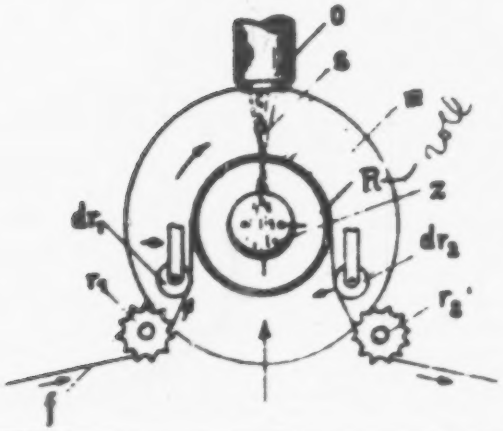


Abb. 2.



Translation.

Issued 5th. February, 1924.

GERMAN PATENT OFFICE.
PATENT SPECIFICATION No. 389318.
Class 42g, Group 17.
(V 16360 IX/42g.)

Joseph Massolle of Berlin-Grunewald, Hans Vogt of Berlin-Wilmersdorf, and Dr. Josef Engl of Berlin-Grunewald.

DEVICE FOR PHONOGRAPHS WITH LINEAR PHONOGRAM CARRIERS.

Addition to Patent 387058.
Patented in the German Reich as from 25th. March 1921.
Limit of duration: May 22, 1938.

It is known that the recording and reproduction of sound waves by means of linear phonogram carriers, such as film bands, steel wires, etc., can only be carried out successfully if the speed of the sound carrier remains constant both in recording and in reproducing, no variations of speed occurring during either operation. This is specially important in the case of musical processes, which are known to be peculiarly sensitive to the slightest fluctuations in speed.

According to the object of the main patent 387058 this constant speed of the phonogram carrier at the recording, i. e., the control point is ensured by coupling the phonogram carrier to a rotating centrifugal mass.

In accordance with the invention the constant speed device is constructed in such a way that the re-

cording, i. e., the control point of the phonogram carrier is situated between the two rollers provided with centrifugal masses. The film consequently runs under tension between the two rollers, so that its motion is rendered more uniform. The irregularities often caused by toothed gear or by the mechanical oscillations to which sections (stretches) of film are subject can be avoided by placing the recording, i. e., the control point of the phonogram carrier on the periphery of one roller which is provided with a gyrating mass.

Constructional examples of the invention are shown in the illustrations. The phonogram carrier, which in the case of these forms of construction is a film band, moves over the rollers r^1 and r^2, which are suitably interconnected by means of gear or belt drives, and of which preferably the roller r^2, driven direct by the motor, is provided with teeth. Both rollers are rigidly connected to gyrating masses m^1 and m^2, which give the required uniformity of motion to the section of film f running under tension between them. Between the rollers r^1 and r^2, suitably located in a casing h, is the electric organ z, which is sensitive to light and which is influenced by a ray of light coming from o and passing through the film. The rollers dr^1 and dr^2 press the film against the conveying roller r^2.

Fig. 2 shows another form of construction of the invention which avoids the small irregularities frequently caused by the teeth or by the sections (stretches) of film between r^1 and r^2, which tend to be subject to mechanical oscillations.

The film f is conveyed by the roller r^1 to the control point s and is carried away from this point by the roller r^2. Between these conveying rollers the film is guided over the periphery of a larger roller R, upon which it lies closely owing to adhesion, even during the rotary movement. As the roller is either rigidly con-

nected with the centrifugal mass *m* or can itself be so constructed that it forms such a mass, the film continues to move with the same uniformity of speed as the surface of the roller *R*. The rollers dr^1 and dr^2, which are mounted in spring bearings, serve to press the film against the roller *R* and to compensate any irregularities of motion. The necessary rays of light for playing upon, i. e., penetrating the film are thrown upon it by means of the lens *O* in the form of a narrow line. On reproduction the rays of light pass through the film band and fall on the photocell *z*, which can, as in this instance, be situated within it. To this end the roller is either partly constructed of transparent material (such as glass) or the portion of the film bearing the sound impressions projects over the opaque portions of the roller.

PATENT CLAIM.

Device for phonographs with linear phonogram carriers according to Patent 387058, characterized by the fact that the recording, i. e., the control point (*s*) of the phonogram carrier (*f*) is placed between the two rollers (r^1 and r^2), each of which is provided with a centrifugal mass (m^1 or m^2), or, in case a roller *R*, likewise fitted with a centrifugal mass (*m*), is used, is situated on the periphery of such roller.

DEFENDANTS' EXHIBIT NO. 109.

DEUTSCHES REICH

AUSGEGEBEN
AM 5. FEBRUAR 1924

REICHSPATENTAMT

PATENTSCHRIFT

U. S. DISTRICT COURT
M. D. PENN.
DEFT. EX. 109

— № 389319 —.

KLASSE 42g GRUPPE 17

(V 16430 IX/42g)

Joseph Massolle in Berlin-Grunewald, Hans Vogt in Berlin-Wilmersdorf und Dr. Josef Engl in Berlin-Grunewald.

Einrichtung für Phonographen mit linearem Phonogrammträger.

Zusatz zum Zusatzpatent 389318.

Patentiert im Deutschen Reiche vom 10. April 1921 ab.

Längste Dauer: 22. Mai 1938.

Im Patent 389318 ist eine Gleichlaufeinrichtung für lineare Phonogrammträger geschützt, die an der Projektionsstelle zwecks Konstanthaltung der Geschwindigkeit mit einer Schwungmasse gekuppelt sind. Der Antrieb des linearen Phonogrammträgers oder Tonbandes erfolgt jedoch nicht unmittelbar an der Projektionsstelle, sondern vor oder hinter derselben. Nach der Erfindung wird die Antriebsstelle des Tonbandes unmittelbar an die Projektionsstelle verlegt. Das Antriebsglied läßt sich dann so ausgestalten, daß das Ein- und Auskämmen der Fortschaltzähne in die Perforation ohne Rückwirkung auf die Geschwindigkeit des Bildbandes an der Projektionsstelle ist, was für die Tonvorführung von Wichtigkeit ist.

Die Abbildung zeigt ein Ausführungsbeispiel des Erfindungsgegenstandes. Die Achse *a*, gelagert bei *b* und *c*, trägt an einem Ende die Fortschaltrolle *d*, die mit den üblichen, in die Perforation des Tonbandes eingreifenden Zakken versehen ist. Auf einen Teil des Umfanges dieser Rolle, dem Abstand der Druckrollen *e* und *f* voneinander entsprechend, liegt der Film *g* fest auf. Mit der Achse verbunden sind ferner die Antriebsscheibe *h*, die auch ein Zahnrad oder ein anderes zweckdienliches Mittel sein kann, sowie die Schwungmasse *i*, welche der Achse und damit der Rolle *d* gleichförmige Drehgeschwindigkeit erteilt. Infolgedessen bewegt auch das Tonband sich mit gleichförmiger Geschwindigkeit, beispielsweise in der Richtung *f-e*. Diese Rollen *e*, *f* drücken das Band dabei fest an die Rolle *d* an, so daß es auf der ganzen Länge von *f* bis *e* infolge der in die Perforation eingreifenden Schaltzähne unverrückt aufliegt. Das Ein- und Auskämmen der Schaltzähne erfolgt dabei unter dem Druck der Rollen *f* und *e*, so daß sich Erschütterungen des Bildbandes an der Projektionsstelle nicht mehr bemerkbar machen. Vorteilhaft werden die freien Filmenden *g*, *g* durch Vorwickelrollen in der bei Bildkinematographen üblichen Weise so geführt, daß sie eine leichte Schleife bilden. Für Aufnahmezwecke, wobei das aufzunehmende, rhythmisch gesteuerte Licht das Tonband nur an der Schichtoberfläche zu belichten braucht, kann eine massive Rolle *d* verwendet werden, auf welcher das Tonband mit seiner ganzen Breite aufliegt.

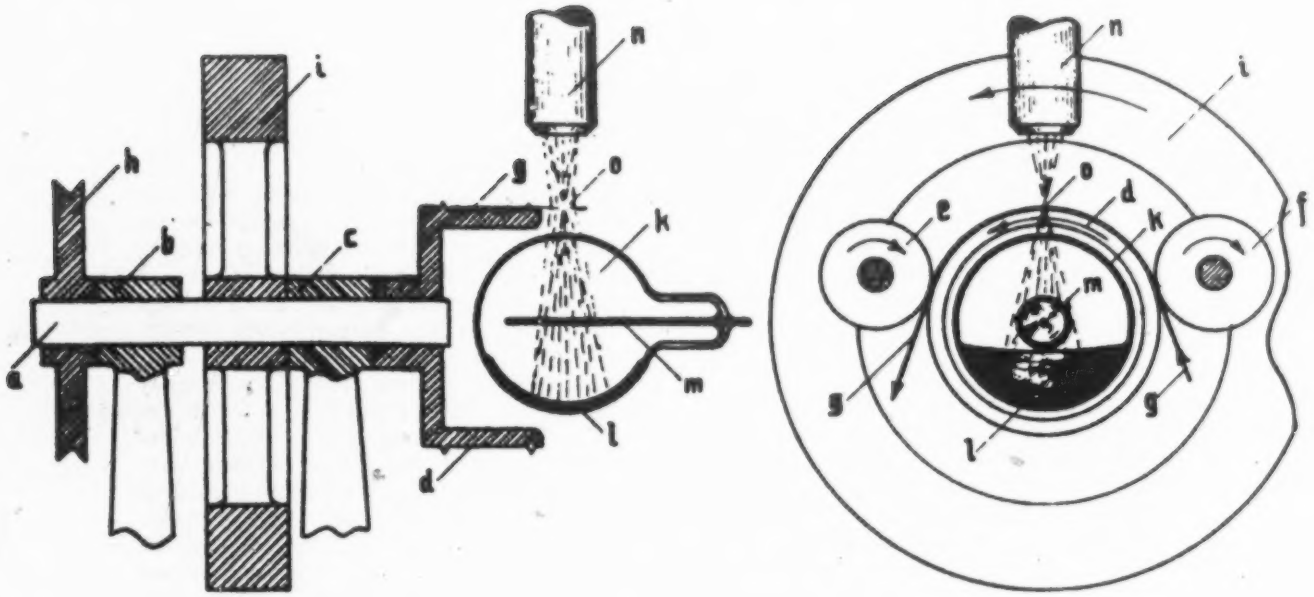
Für Wiedergabezwecke, wobei das durch ein Objektiv *n* in einer schmalen Linie zusammengefaßte Licht der Projektionslichtquelle bekanntlich durch den Film auf das lichtempfindliche Organ, z. B. die Zelle *k* mit der Kathode *l* und der Anode *m*, fällt, ist eine besonders konstruierte Rolle erforderlich. *d* in der Abbildung ist ein Ausführungsbeispiel, bei welchem das die Tonzeichen tragende Stück des Bandes über den Rand der Rolle hinaus-

ragt. Es können dabei die Tonzeichen auch zwischen den beiden Perforationsreihen liegen, indem nur eine Perforationsreihe zur Fortschaltung benutzt wird und die andere Seite des Tonbandes entweder ohne besondere Führung mitläuft oder über ein mitlaufendes bzw. besonders angetriebenes Rad mit oder ohne Schaltzähne läuft.

Patent-Ansprüche:

1. Einrichtung für Phonographen mit linearem Phonogrammträger nach Patent 389318, dadurch gekennzeichnet, daß die das Tonband fortbewegende Zackenrolle (*d*) die mit der Schwungmasse verbundene Rolle bildet und somit unmittelbar an der Projektionsstelle des Tonbandes wirksam ist.

2. Einrichtung nach Anspruch 1, dadurch gekennzeichnet, daß für Wiedergabezwecke der mit den Tonzeichen versehene Teil der Tonbänder über die Zakkenrolle (*d*) hinausragt, so daß das Lichtstrahlenbündel ungehindert auf das lichtelektrische Organ fallen kann.



Translation.

Issued 5th February, 1924.

GERMAN PATENT OFFICE.

PATENT SPECIFICATION No. 389319.

Class 42g, Group 17.

(V 16430 IX/42g.)

Joseph Massolle of Berlin-Grunewald, Hans Vogt of Berlin-Wilmersdorf, and Dr. Josef Engl of Berlin-Grunewald.

DEVICE FOR PHONOGRAPHS WITH LINEAR PHONOGRAM CARRIERS.

Addition to Supplementary Patent No. 389318.

Patented in the German Reich as from April 10, 1921.

Limit of duration: May 22, 1938.

Patent No. 389318 covers a constant speed device for linear phonogram carriers which, in order to maintain uniformity of speed, are connected at the point of projection with a centrifugal mass. The linear phonogram carrier or sound band is, however, not driven directly at the place of projection, but before or after it. In accordance with the present invention the driving position of the sound band is transferred directly to the point of projection. The driving member can then be so formed that the engagement and disengagement of the propulsion teeth with the perforations is without reaction on the speed of the picture band at the place of projection, which is a point of importance for the production of sound.

The illustration shows one form of construction of the object of the invention. The shaft *a*, mounted on

bearings at *b* and *c*, carries at one end the propulsion roller *d*, which is provided with the usual teeth engaging in the perforations of the sound band. The film *g* lies closely upon a portion of the periphery of the roller corresponding to the distance between the pressure rollers *e* and *f*. Likewise connected with the shaft are the driving pulley *h* (which can also be a gear or other suitable device), and the centrifugal mass *i*, which imparts a constant rotary motion to the shaft and therefore to the roller *d*. Consequently, the sound band also moves at a uniform speed, in this instance in the direction from *f* to *e*. During such motion the rollers *e* and *f* press the band tightly against the roller *d*, so that it contacts without displacement throughout its length from *f* to *e* owing to the transmission teeth engaging in the perforations. The engagement and disengagement of the transmission teeth takes place under the pressure of the rollers *f* and *e*, so that no shaking of the picture band at the point of projection can be noticed. It is of advantage to guide the loose film ends *g* and *g* by means of preliminary winding rollers, in the usual manner adopted in picture cinematographs, in such a way that they form a slight loop. For recording purposes for which the recording rhythmically controlled light only has to illuminate the surface layer of the sound band, a solid roller *d* can be used upon which the sound band lies throughout its width.

For reproduction purposes for which the collected light from the source of light projection are concentrated into a narrow line by means of an objective *n*, as is known, and penetrate the film, falling upon the organ sensitive to light (as, for example, the cell *k* with the cathode *l* and anode *m*) a specially constructed roller is necessary. In the illustration, *d* is a constructional example in which the portion of the band bearing the sound impressions projects beyond the edge of the roller. In this case the sound impressions can also

lie between the two rows of perforations, only one row being used for the purposes of propulsion, while the other side of the sound band either runs concomitantly without special guidance or moves over a concomitantly running or specially driven wheel, with or without teeth.

PATENT CLAIMS.

1. Device for phonographs with linear phonogram carriers in accordance with Patent 389318, characterized by the fact that the toothed roller (*d*) propelling the sound band is connected with the centrifugal mass and is thus effective directly at the place of projection of the sound band.

2. Device in accordance with Claim 1, characterized by the fact that, for reproduction purposes, the portion of the sound bands bearing the sound impressions projects beyond the toothed roller (*d*), so that the light ray bundle can fall without impediment upon the photo (light) electric organ.

DEFENDANTS' EXHIBIT NO. 110.

PATENT SPECIFICATION

Convention Date (Germany): April 9, 1921. **178,133**

Application Date (in United Kingdom): April 10, 1922. No. 10,221/22.

Complete Accepted: Jan. 4, 1923.

COMPLETE SPECIFICATION

Improvements in Apparatus for Reproducing Sound.

We, JOSEPH MASSOLLE, Engineer, of 60, Cuno Strasse, Berlin-Grunewald, HANS VOGT, Engineer, of 49, Babelsberger Strasse, Berlin-Wilmersdorf, and JOSEF ENGL, Doctor of Physics, of 53, Hohenzollerndamm, Berlin-Grunewald, all in Germany, of German nationality, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The present invention relates to the propelling mechanism for speaking cinematograph films and film phonogram records from which sound is reproduced by photo-electric means, and relates particularly to phonographs of that type in which the record is supported on and driven by a toothed roller as it passes the light projecting point for the purpose of keeping the speed of delivery constant.

According to the present invention propelling mechanism of the type set forth is employed in which that part of the film which is provided with the sound record projects beyond the toothed roller, so that the light beam can traverse it unimpeded and act upon the sensitive element.

The drawing illustrates a constructional example.

For the purpose of sound reproduction, the light, concentrated by a lens *n* into a narrow beam (the light projection source), is projected in the well known manner through the moving strip record upon the sensitive element, that is, the cell *k* with the cathode *l* and the anode *m*. In the drawing, *o* illustrates the manner in which the part of the film carrying the sound record projects beyond the edge of the roller.

The shaft *a* journalled at *b c* supports at one end the propelling roller *d* which is provided with the usual projections engaging in the perforations of the record. At that part of the periphery of this roller *d* corresponding to the space which separates the pressure rolls *e f* one from the other, the film *g* is closely applied to the roller *d*. Connected with the shaft is likewise the driving wheel *h* (preferably a gear wheel) and the heavy body *i* which imparts to the shaft and consequently to the roller *d* a uniform speed of rotation. Consequently, the record also moves with uniform speed, preferably in the direction from *f* to *e*. The rollers *e f* press the record firmly upon the roller *d* so that it rests smoothly upon the entire surface from *f* to *e*, the teeth of *d*, engaging in the perforations of the record. The engagement of these teeth takes place under the pressure of the rolls *f*, *e*, so that jerks of the record at the light projection point cannot occur. The record strip previous to its application to the surface of *d* is preferably so guided by preliminary rolls in the usual manner that it forms a slight loop.

Having now particularly described and ascertained the nature of our said invention, and in what manner the same is to be performed, we declare that what we claim is:—

1. In photo-electric sound reproducing apparatus for speaking cinematograph films and film phonogram records, wherein propelling mechanism of the kind set forth is employed, the arrangement whereby that part of the film which is provided with the sound record projects beyond the toothed roller, so that the light beam can traverse it unimpeded and act upon the sensitive element.

2. The apparatus for reproducing sound from speaking cinematograph films and film phonogram records substantially as described with reference to the accompanying drawings.

Dated this 10th day of April, 1922.

SEFTON-JONES, O'DELL & STEPHENS,
Patent Agents,
285, High Holborn, London, W.C. 1,
Agents for the Applicants.

PATENT SPECIFICATION

Convention Date (Germany): April 9, 1921.

178,133

Application Date (in United Kingdom): April 10, 1922. No. 10,221/22.

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The present invention relates to the propelling mechanism for speaking cinematograph films and film phonogram records from which sound is reproduced by photo-electric means, and relates particularly to phonographs of that type in which the record is supported on and driven by a toothed roller as it passes the light projecting point for the purpose of keeping the speed of delivery constant.

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Having now particularly described and ascertained the nature of our said invention, and in what manner the same is to be performed, we declare that what we claim is:—

1. In photo-electric sound reproducing apparatus for speaking cinematograph films and film phonogram records, wherein propelling mechanism of the kind set forth is employed, the arrangement whereby that part of the film which is provided with the sound record projects beyond the toothed roller, so that the light beam can traverse it unimpeded and act upon the sensitive element.

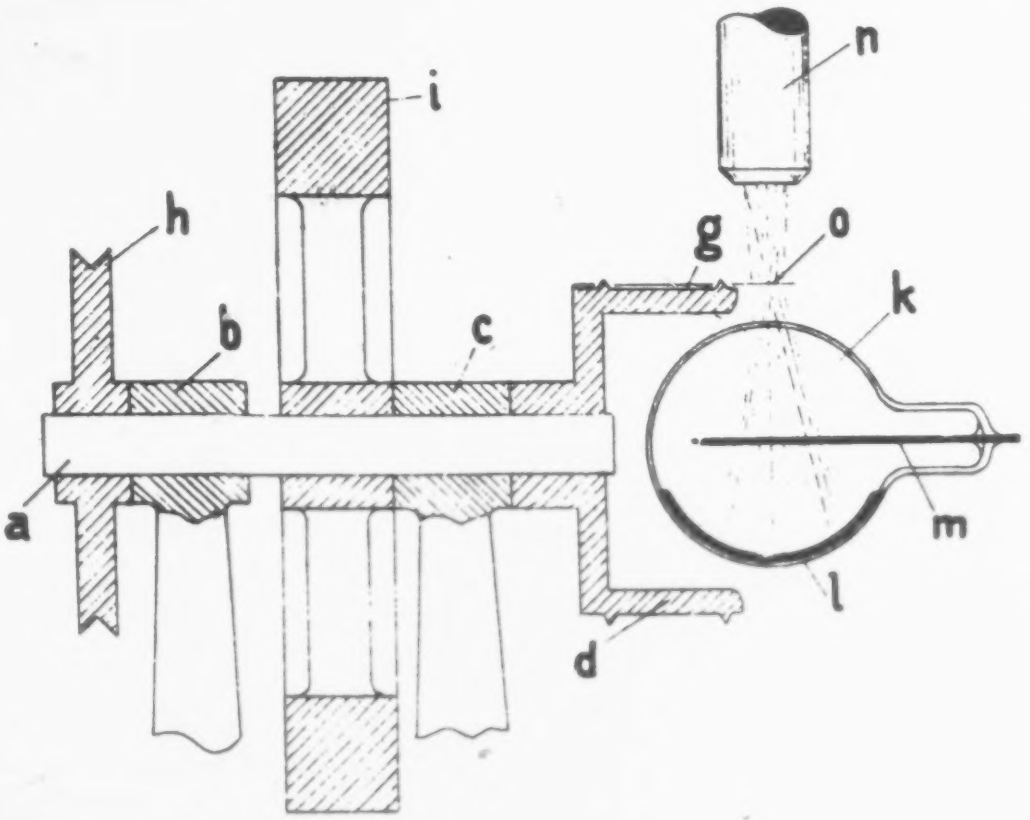
2. The apparatus for reproducing sound from speaking cinematograph films and film phonogram records substantially as described with reference to the accompanying drawings.

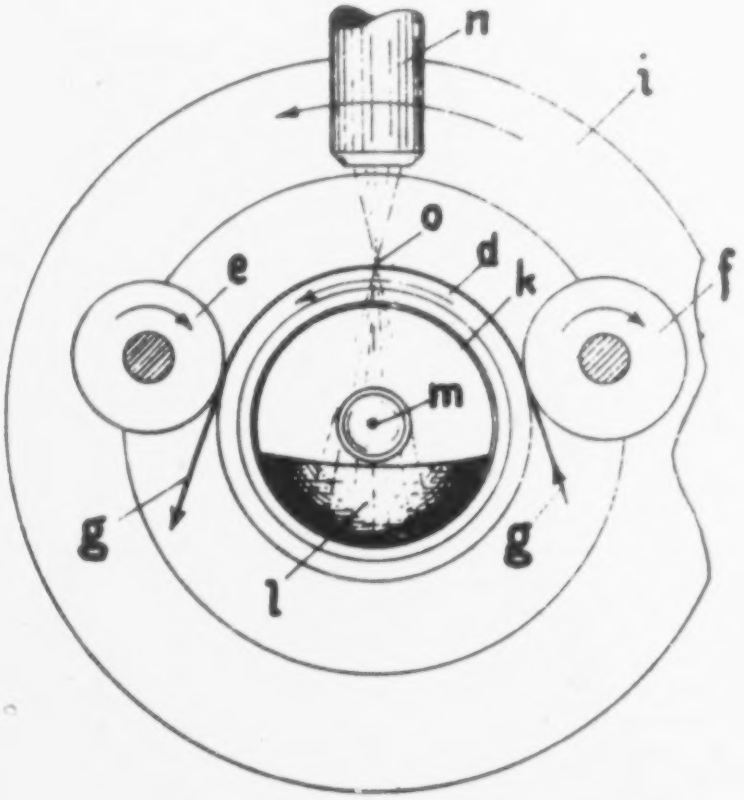
Dated this 10th day of April, 1922.

SEFTON-JONES, O'DELL & STEPHENS,
Patent Agents,
285, High Holborn, London, W.C. 1,
Agents for the Applicants.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1923.

[Price 1/-]





[This Drawing is a reproduction of the Original on a reduced scale]

Malby & Sons Photo-Litho

DEFENDANTS' EXHIBIT NO. 111.

British Patent Office Certificate, Containing Application as Open to Public Inspection of British Patent No. 178,133, to Massolle, Vogt and Engl, Corresponding Application as Originally Filed in Germany, and Translation, and Assignment of August 16, 1924, from Patentees to Tri-Ergon, A. G. Zurich.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 112.

U. S. DISTRICT COURT
M. D. PENN.
DEFT. EX. 112

DEUTSCHES REICH

AUSGEGEBEN AM
23. AUGUST 1925
PATENT OFFICE

REICHSPATENTAMT

PATENTSCHRIFT

№ 417967

KLASSE 42g GRUPPE 17

(Tri-Ergon A.-G.)

Tri-Ergon A.-G. in Zürich *).

Verrichtung zur photographischen Aufnahme optisch-akustischer Vorgänge, und deren Wiedergabe mittels konstanter Lichtquelle.

Patentiert im Deutschen Reiche vom 4. März 1919 ab.

Für die Zwecke der akustischen Kinematographie ist es bekanntlich erforderlich, die akustischen Vorgänge synchron aufzunehmen und wiederzugeben zu können. Die Schwierigkeiten zur Verwirklichung dieser Aufgabe liegen insbesondere in der verzerrenden Wirkung der Trägheit der bei der Aufnahme und Wiedergabe benutzten Vorrichtungen. Akustische Kinematographie kann mithin auch nicht einwandfrei dadurch verwirklicht werden, daß für das Aufnahmeverfahren allein diese Schwierigkeiten behoben werden, während das Wiedergabeverfahren mit den bisher vorhandenen Nachteilen durchgeführt wird.

Die Erfindung besteht in der Verwendung von möglichst verzerrungsfrei und störungsfrei arbeitenden Vorrichtungen zur Umwandlung der Sprechstromschwankungen in Lichtschwankungen und umgekehrt.

Die Aufnahme, deren Schwierigkeit darin besteht, die akustischen Frequenzen unverzerrt und ohne Zeitdifferenzen zu registrieren, wird dadurch ermöglicht, daß die Querschnittsform des Filmbandes der [illegible] akustischen Frequenzen [illegible] derart, daß [illegible] an sich bekannt [illegible] Frequenzen [illegible] wird eine [illegible] auf eine lichtelektrische Zelle einwirkt. Die Wirkung der lichtelektrischen Zelle, die verstärkt, wie an sich bekannt, zur Allmelodie [illegible] wird erhöht durch Einschaltung in einen durch ungedämpfte Hochfrequenzschwingungen erregten Kondensatorkreis. Die zur Aufnahme dienende, den akustischen Frequenzen trägheitslos folgende Lichtquelle ist vorteilhaft eine leuchtende Gasstrecke, die sich in einem Vakuumgefäß befindet.

Die Erfindung kann praktisch derart ausgeführt werden, daß, während auf einem Film der optische Teil eines Ereignisses in normaler Weise kinematographisch fixiert wird, die hiermit verbundenen akustischen Vorgänge, Töne und Geräusche, in bekannter Weise auf einen schallaufnehmenden Apparat (Mikrophon) wirken und sich in elektrische Stromschwankungen umsetzen. Diese beeinflussen eine praktisch trägheitsfreie Lichtquelle, insbesondere eine leuchtende Gasstrecke, die der [illegible] Schallwellen erzeugten Stromschwankungen [illegible] selbst Eigengeräusche [illegible]

Von dieser Lichtquelle kann [illegible]

*) Vom dem Patentsucher [illegible]

Quertrillen zu belichten. Hierbei muß die Dauer der Filmgeschwindigkeit, der Streifenbreite, entsprechend, derart gewählt werden, daß die Charakteristik der Sprache nicht gestört wird. „Da aber bekanntlich der Film [illegible] verschieden passiert erfolgt die Belichtung an einer etwas vor oder zurückliegenden Stelle des Films, die sich aber stetig [illegible]

Um die optisch aufgezeichneten Sprachschwingungen mittels der Streifenschwärzung wiederzugeben, wird letzteren von einer konstanten Lichtquelle Licht gestrahlt, dessen Lichtbündel durch das vorbeilaufende Filmband rhythmisch in seiner Intensität geändert wird und auf eine lichtelektrische Zelle, z. B. Kaliumhydrür auf Edelgasfüllung, fällt. Man benutzt die Widerstandsänderungen der Zelle, um in einem mit ungedämpfter Hochfrequenz gespeisten Schwingungskreis, zu dessen Kondensator die Zelle parallel geschaltet ist, Stromschwankungen hervorzurufen, indem die Dämpfung dieses Kreises durch den durch die Zelle bedingten Parallelwiderstand beeinflußt wird.

Auf diese Weise lassen sich auch in großen Räumen, unter Benutzung bekannter Verstärkereinrichtungen, genügende Schallintensitäten erzeugen.

Patent Anspruch:

1. Verrichtung zur photographischen Aufnahme sprechakustischer Vorgänge und deren Wiedergabe mittels konstanter Lichtquelle, dadurch gekennzeichnet, daß bei der Aufnahme die Querbelichtung des Tonbandes mittels einer in der Art einer in einem Vakuumgefäß brennenden Gasstrecke, den Schallfrequenzen trägheitslos folgenden Lichtquelle erfolgt und die bei der Wiedergabe verwendete konstante Lichtquelle eine lichtelektrische Gasstrecke, z. B. Alkalimetallzelle, beeinflußt.

2. Verrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die lichtelektrische Zelle zu einem mit ungedämpfter Hochfrequenz gespeisten Kondensatorkreis parallel geschaltet ist, so daß elektrische Stromschwankungen im Rhythmus der photographischen Aufzeichnungen hervorgerufen werden.

Translation.

GERMAN PATENT 417967 CLASS 42 G 17

Patentee—Tri-Ergon
Filed March 4, 1919
Published August 22nd, 1925

Title—Method for the Photographic Recording of Optical and Acoustical Sequences and Their Reproduction by Means of a Constant Light Source.

For the purposes of talking motion picture, it is well known that it is required to record and reproduce the optical and acoustic sequences in synchronism. The difficulties in the way of a practical realization thereof are fundamentally concerned with the distortional effect due to the inertia of the apparatus for recording and reproducing. Talking motion pictures, therefore, cannot be commercially realized by solely removing all the difficulties in the recording methods and using present day reproduction methods with their known difficulties.

The invention relates to apparatus for the translation of a voice current into light variations, and vice-versa, which is practically distortionless and free from outside disturbances.

Recording, in which the difficulty is that the sound frequencies must be recorded without distortion and without time lag, is made possible by the illumination of a film by a light source which varies in accordance with the sound frequencies without time lag. Such light sources per se are known. In order to similarly reproduce the photographically recorded sound frequencies without distortion, a constant light source is employed, which activates a photoelectric cell. The activity of the photoelectric cell, which is preferably the well-known alkali metal cell is increased by shunt-

ing it about a condenser circuit coupled to a source of high frequency undamped oscillations. The light source used for the inertialess recording of the sound frequencies is preferably a luminous gas discharge in an evacuated enclosure.

The invention may be carried on commercially by recording the optical sequences upon the film in the usual manner. The accompanying acoustical sequences (sound and noise) activate the pick-up device (microphone) and are there converted into electrical variations. These latter modulate a practically inertialess light source, more particularly a glowing gas discharge which accurately varies with the current induced by the source of sound without introducing variations originating in itself.

In place of this light source, a lamp with a thermionic light emission may be employed which in an adaptable form is similarly inertialess in its response.

These light variations are employed to illuminate a transverse strip of the moving film in any known manner. Care must be exercised in determining the speed at which the film moves with relation to the width of the illuminated strip in order not to adversely effect the speech characteristics. In that, as is well known, the film passes the objective intermittently, this illumination occurs at a place either in advance of, or on the far side of, the objective where the film is in uniform motion.

In order to reproduce the photographically recorded sound frequencies by means of the striations, the latter are illuminated by means of a constant light source, and the light beam is varied in intensity by means of the passing film and activates a photo-electric cell, (for example an alkali-hydride argon-filled cell). The variations in resistance of the cell cause variations in the current of a circuit oscillating at high frequency,

the cell being shunted around the condenser thereof, in that the damping of this circuit is controlled by the resistance of the cell in parallel.

By this method sound intensities sufficient for large auditoriums are procurable, with the use of known amplifying arrangements.

Patent Claims

1. Device for the photographic recording of optic-acoustic events and their reproduction by means of a constant light source, having the distinctive feature that in connection with the recording, the cross illumination of the film takes place by means of a light source following—in the form of a gaseous path luminous in a vacuum receptacle—the sound frequencies in an inertialess manner and that the constant light source used in the reproduction influences a photo-electric gas cell, for instance an alkali metal cell.

2. Device in accordance with Claim 1, having the distinctive feature that the photo-electric cell is inserted in parallel with a condenser circuit fed with undamped high frequency, so that electric current fluctuations are produced in rhythm with the photographic recordings.

DEFENDANTS' EXHIBITS NOS. 113-A AND 113-B.

Two Nullity Decisions of German Patent Office Re German Patent No. 417,967, to Vogt, Engl and Massolle, With Translations.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 114.

SMITHSONIAN INSTITUTION
UNITED STATES NATIONAL MUSEUM
WASHINGTON, D. C.

114

U. S. DISTRICT COURT
M. D. PENN.
DEFT. EX. 114

SMITHSONIAN INSTITUTION

UNITED STATES NATIONAL MUSEUM

TO ALL PERSONS TO WHOM THESE PRESENTS SHALL COME, GREETING:

THIS IS TO CERTIFY that this is a true copy of original entries made in the National Museum Catalog in the Division of Engineering of certain specimens received by the United States National Museum, under the Smithsonian Institution, in Washington, D. C.

In testimony whereof I have hereunto set my hand and caused the seal of the Smithsonian Institution to be affixed, at the City of Washington, this 1st day of June in the year of our Lord one thousand nine hundred and thirty-three.

A. Wetmore

Assistant Secretary, Smithsonian Institution.

Attest: H. S. Bryant
Chief of Correspondence and Documents Division.

	Object No.	Original No.	NAME.	Sex	LOCALITY.	When Produced.	NATURE OF OBJECT.		Consecutive Register No.	Remarks.	Name of	How Obtained.	Date.	Value.	No. of Specimens.	Remarks.
253	960	12	Bl. Clone Gliding machine Model - 1896.				A	1	49.697	Gift of	Octave Chanute		January 27 1909		1	
253	000	2	Com. Cm. Steel -		town Ladysmith	Natal		2	49.799	Gift of	Russell Hastings	Millward,	Feb 25 1910		1	
253	711	3	Aneroid barometer				M	3	47.273	Gift of	Blanden & Woolley,		March 18 1909		1	
253	197	4	Watch movement		Nickel Cryst Co		M	4	49.971	Gift of	Capt Cecil Wm Smith,		Feb 6 1909		1	
253	795	5	" "		J. C. Ayres		M	5	"	"	"	"	"	"	1	
253	799	6	" "		Cleveland Stamping Co		M	6	"	"	"	"	"	"	1	
253	800	7	" "		No 7385 Rowlandson		M	7	"	"	"	"	"	"	1	
253	801	8	" "		No 9.690 W. H. Bellingford		M	8	"	"	"	"	"	"	1	
253	802	9	" "		No 20.426 Lemaire		M	9	"	"	"	"	"	"	1	
253	803	10	" "		No 12.355 J. Cunningham		M	10	"	"	"	"	"	"	1	
253	804	11	" "		Swiss patent lever		M	11	"	"	"	"	"	"	1	
253	805	12	" "		No 148 Edmund Gordon		M	12	"	"	"	"	"	"	1	
253	806	13	" "		No 935 Eardley Norton		M	13	"	"	"	"	"	"	1	
253	807	14	Watch silver plate		No 22.648 Jos Ezekiel		M	14	"	"	"	"	"	"	1	
253	808	15	Watch movement		No 0.645 - Breguet		M	15	"	"	"	"	"	"	1	
253	809	16	" "		No 1.705 Berthoud		M	16	"	"	"	"	"	"	1	
253	810	17	" "		French Style detent		M	17	"	"	"	"	"	"	1	
253	811	18	" "		English - (Lever or French)		M	18	"	"	"	"	"	"	1	
253	764	19	Multiple-wing gliding machine - Model - 1896.				A	19	49.922	Gift of	Octave Chanute		March 30 1909		1	
255	151	20	Oscillating-wing gliding machine - Model - 1896-1902.				A	20	50.019	"	"	"	"	April 24 1909	1	
253	819	21	French Watch Movement with small pinion				M	21	50003	Gift of	Dr Thomas	Darbyshire	Brough	April 21 1909		
253	820	22	English Watch Movement - with jewelled jewels				M	22	"	"	"	"	"	"	1	
253	757	23	Berliner Gramophone with Clarke improvement				Misc	23	49.940	Lent by	Alfred Clark		April 6 1909		1	
253	841	24	Georgia Cotton Gin				Misc	24	49.998	Gift of	Chas F. Morgan		April 27 1909		1	
253	972	25	Photo Theodolite				M	25	49.676	Transfer	U. S.	[illegible]				

Alexander Graham Bell's Talking Machine Accessions

Catalogue No.	Accession No.	Signal No.	Name.	Sec.	Locality.	When Collected.	Received from —	Collected by —	When Entered.	No. of Spec.	Remarks.
	/				recording and reproducing						
287,653 to 287,694			Walnut box containing a phonograph machine.				Alexander Graham Bell, Volta Bureau, 35th & O sts. N.W.				A small made instrument having a 7-1/2-light under, with various attachments, keeper is wooden & is 13 pieces of rubber 13" in diameter
287,695 C	"		Pine box, 11-1/2" wide, 14-1/2" long, 15" high								containing 13 glass disks, 13 1/2" in diameter (1 of 2 broken)
287,696 C	"		Walnut base, 12" sq. carrying		underplate metal plate with sockets, various attachments etc, 6 pieces						(1 steel piece, may belong to something else.)
287,697 C	"		Unfinished Walnut base, 13-1/2 X 14-1/2 inches.								a underplate metal disk operated by spring with various reproducing appliances - 3 pcs
287,698 C	"		" " " " frame. crank		heavy metal disk, 10-1/2" in diam (broken) revolved by wheel supporting a metal bar, 9"						Various recording and reproducing attachments. 2 loose disks, 6" in diam. 1 loose disk, 8" in diam.
287,699 C	"		" " " " 18 x 18-1/2"		diameter, revolved by wheel crank,						
287,700 C	"		" " " " 18-1/4 x 18-1/2"		upright vertical metal disk 19-3/4" inches in diameter revolved by wheel mechanism & perpendicular metal bar 6 inches						
287,701 C	"		" " " " 11 by 20 inches		in diameter with crank on side,						
287,702 C	"		Walnut frame 4-1/2" sq.		as supporting wooden frame with diaphragm, 9-1/4 in. high.						two hospital receiving pedestal frames, 8" in diameter
287,703 C	"		Unfinished walnut base,		5 x 7-1/2". 4 iron carrying metal shaft 7" long, with small hand wheel 9 inches high, diaphragm at top						log also has "zig zag recorder with flexible stylo, C.A.B."
287,704 C	"		Unfinished walnut frame.		(not complete) upright, 9 inches high						(not complete)
287,705 C	"		Iron frame, base 6 by 16"		supporting apparatus						log also has "Disk — phonographs. C. A. B."
287,706 C	"		Walnut base 7-3/4 by 13-1/4		heavy brass frame carrying counterbalanced disk 7" in diameter, "heavy brass metal disk with handle for bearing, brass frame carrying						("upper" larger of disk fragments, apparently made of general diameter, diaphragm recording
287,707 C	"		Oblong walnut base, 6x8"		shaft revolved by the aid of a worm cylinder 1-10 inch in						log has, in triangle frame.
287,708 C	"		Plain walnut frame,		3-1/4 x 8-1/2", 6-3/4" high carrying shaft with crank.						marked in center "Bell phonogram" made Nov 11, 1881, C.A.B."
287,709 C	"		Heavy, 10-inch metal disk, 1/2 inch thick,		lead backing, upper face, deep cut.						marked, in center "Bell phonogram" was made November 8, 1881, C.A.B."
287,710 C	"		Heavy, 10-3/4 inch metal disk		1/2 inch thick, lead backing, upper face, deep grooves around						with hole and recorded in center, marked, "C.A.B. December 29, 1881"
287,711 C	"		Lead disk, 10-1/4 inches in diameter		3/4 inch thick, a rough plate, somewhat injured.						
287,712 C	"		Heavy metal disk, deep back		upper face, with central bearing, 6" in diam., 1/2" thick						marked, "Sumner Tainter, April 18, 1881. Volta Laboratory." filled with wax bearing sound record.
287,713 C	"		Heavy metal disk, 6" in diameter		5/16 inch thick, lead back portion, recess						record occupies 1-3/8" space on the rim of disk
287,714 C	"		Heavy metal disk, 5-3/4" in diameter		1/4 inch thick, plain metal portion with 3/8" hole; sound 7/8" thick. Sound record						
287,715 C	"		Heavy metal disk, 4" in diameter		on one face,						
287,716 C	"		Irregular-shaped piece of lead,		2-1/2 inches in diameter, sound record on face						marked, "11, agate cent
287,717 C	"		Brass disk, 6-7/8" in diameter,		3/10" thick, plain face; somewhat broken.						marked, "16th month, 85.
287,718 C	"		Glass glass disk, 13-1/2" made on		in diameter, sound record coating.						A. G. B."

Catalogue No.	Accession No.	Original No.	Name.	Sec.	Locality.	When Collected.	Received from—	Collected by—	When Entered.	No. of Spec.	Remarks.
307,19	65698		Model of Royal Typewriter accelerating key lever action			6	Dept. of Royal Typewriter Co. Thru Pres. A.B. Smith 364-366 Broadway N.Y.		11/23/20	1	Model is working and double size.
19	"		Model of Royal Typewriter roller trip escapement			7	" " "		"	1	Double size working model
19	65,684		Original U.S. Trade Mark #1		Issued by U.S. Patent Office Oct. 25, 1870.	8	Lent by Carroll A. Close, Union Trust Bldg. Wash. D.C.		"	1	Only copy of the trademark issued to Averill Paint Co.
19	65,716		Gasoline Automobile		Designed and constructed by Chas. E. Duryea 1891-1893	9	Gift of Mr. Eugene M. Kleiner Pres. Detroit Cadillac Motor Car Co. Broadway at 62nd St. N.Y.C.		11/18/20	1	The second machine made, same design as #1 but larger motor & wooden parts. Tried first run early in Sept. 1893.
20	63851		Samoan Outrigger Canoe (Model)			10	" "	L. M. Cartwright 736 Florida St. Vallejo, Cal.	12/27/20	1	Local name "paopao"
	65880		Brig "Rising States" 8"		Photographs of model in Peabody Museum, Salem, Mass.	11	" "	Peabody Museum Salem, Mass.	1/3/21	1	Supposed to be the 18 gun armed brig of the Revolutionary Period. See famous "Navy of the U.S." p. 160
	—		Merchant Ship "Friendship"		Photo. of central portion of stern of model in Peabody Museum	12	" "	" "	"	"	"Friendship" built at Salem in 1797 Model made onboard in 1803.
	65903		Maxim Flying Machine		Detail photos. taken by the donor. Also copy of Spec. of Automotive Eq. Apr. 1918	13	" "	E. W. Roberts. Rms. 9-10 Miller Bldg. Cincinnati, Ohio	1/7/21	16	Photos are prints of lantern slides made from originals taken by donor.
	65948 ✓		Berliner Gramophone		Commercial type 1893	14	" "	Emile Berliner 1438 Columbia Rd., N.W. Washington, D.C.	1/14/21	1	Made by U.S. Gramophone Co., Washington, D.C.
	"		"		Electrically driven, 1896	15	" "	" "	"	1	Devised by Emile Berliner
	65983		Chronoscope #1			16	Transferred from U.S. Coast & Geodetic Survey		1/24/21	1	
	"		Dip Circle #9			17	"	" " " "	"	1	Bought de Lacroix 1848+1853
	"		Vertical Circle #37 (in 2 boxes)			18	"	" " " "	"	1	" 1885+1893
	"		Geodetic Level #36			19	"	" " " "	"	1	
21	"		Astronomical Transit #6 (in 2 boxes)			20	"	" " " "	"	1	1848+1852
	66,052		Parts used in Hamilton watches			1	Gift of Hamilton Watch Co. Lancaster, Pa.		2/4/21	1	Framed [illegible] are all the various parts in several styles of Hamilton watches. Can be operated by hand showing parts in motion. Watch Number 449 of this watch made by Chas. E. Bowman, Lancaster, Pa. the parts of the movement between 1879-1892 Marked "C. E. Bowman, Lancaster, Pa. No. 449"
	66,187		Sectional Nine Cylinder Motor			2	Gift of Toledo Ohio Willys-Overland Co.		3/4/21	1	
	66,305		Watch			3	Gift of Chas. E. Bowman,	John J. St. Lancaster, Pa.	3/30/21	1	
307,21	66,366		Nemesis "Aerial Steam Carriage"			4	Made in Museum Work Shop		4/13/21	1	
	66,392		Model of Tahitian Outrigger Canoe			5	Gift of Mr. E. Lloyd Sexton	2007 Jackson St. N.E. Washington, D.C.	4/10/21	1	20 inches long.
	66,451		Columbia "Ordinary" Bicycle			6	Gift of E.H. Sinkens	Mill ville, N.J.	[illegible]	1	54 inch wheel.
	66,456		Victor "Ordinary" Bicycle			7	" Lawrence	Montell Millville, N.J.	"	1	52 " "
	66,499		Gold Watch, engraved gold dial, English make			8	Gift of Geo. W. Starr	21 East Melrose St. Chevy Chase, Md.	"	1	Marked "T. Bennet Liverpool" No. 586
	" "		Silver, double case Watch, [illegible] make, 1762			9	" "	" " "	"	1	" Wm. Cossaingham, Dublin
22	"		Silver, double-case Watch, English make, 1810			10	" "	" " "	"	1	" W. Holland, London #14767

DEFENDANTS' EXHIBIT NO. 115-A.

SMITHSONIAN INSTITUTION
UNITED STATES NATIONAL MUSEUM
WASHINGTON, D. C.

115-A, BC, 20

SMITHSONIAN INSTITUTION
UNITED STATES NATIONAL MUSEUM

TO ALL PERSONS TO WHOM THESE PRESENTS SHALL COME, GREETING:

THIS IS TO CERTIFY that the annexed photographs are a correct representation of a Berliner Gramophone With Clark's Improvement entered in the United States National Museum, under Catalog No. 253757.

In testimony whereof I have hereunto set my hand and caused the seal of the Smithsonian Institution to be affixed, at the City of Washington, this 1st day of June in the year of our Lord one thousand nine hundred and thirty-three.

A. Wetmore

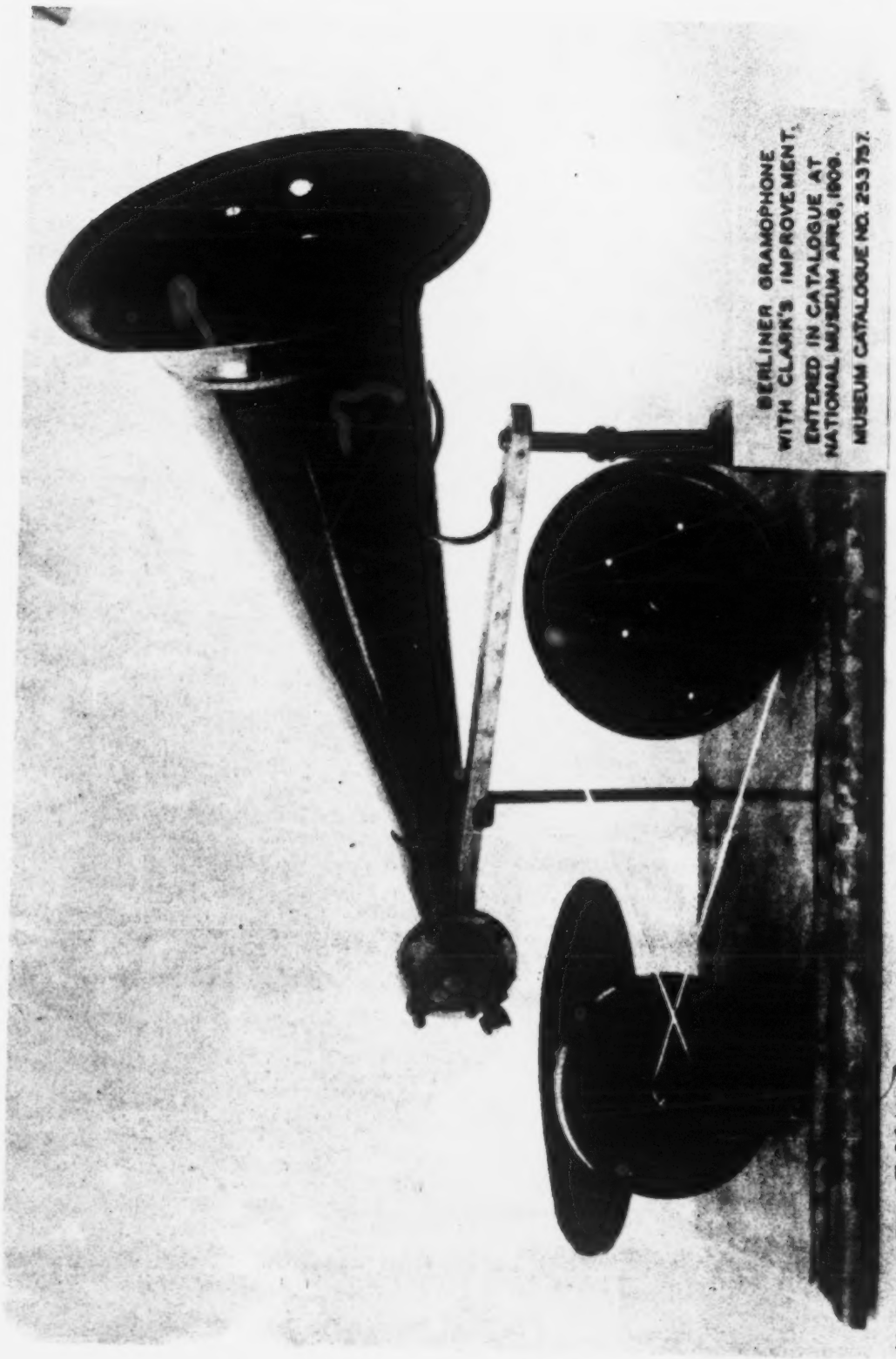
Assistant Secretary, Smithsonian Institution

U. S. DISTRICT COURT
M. D. PENN.
DEFT. EX. 115A

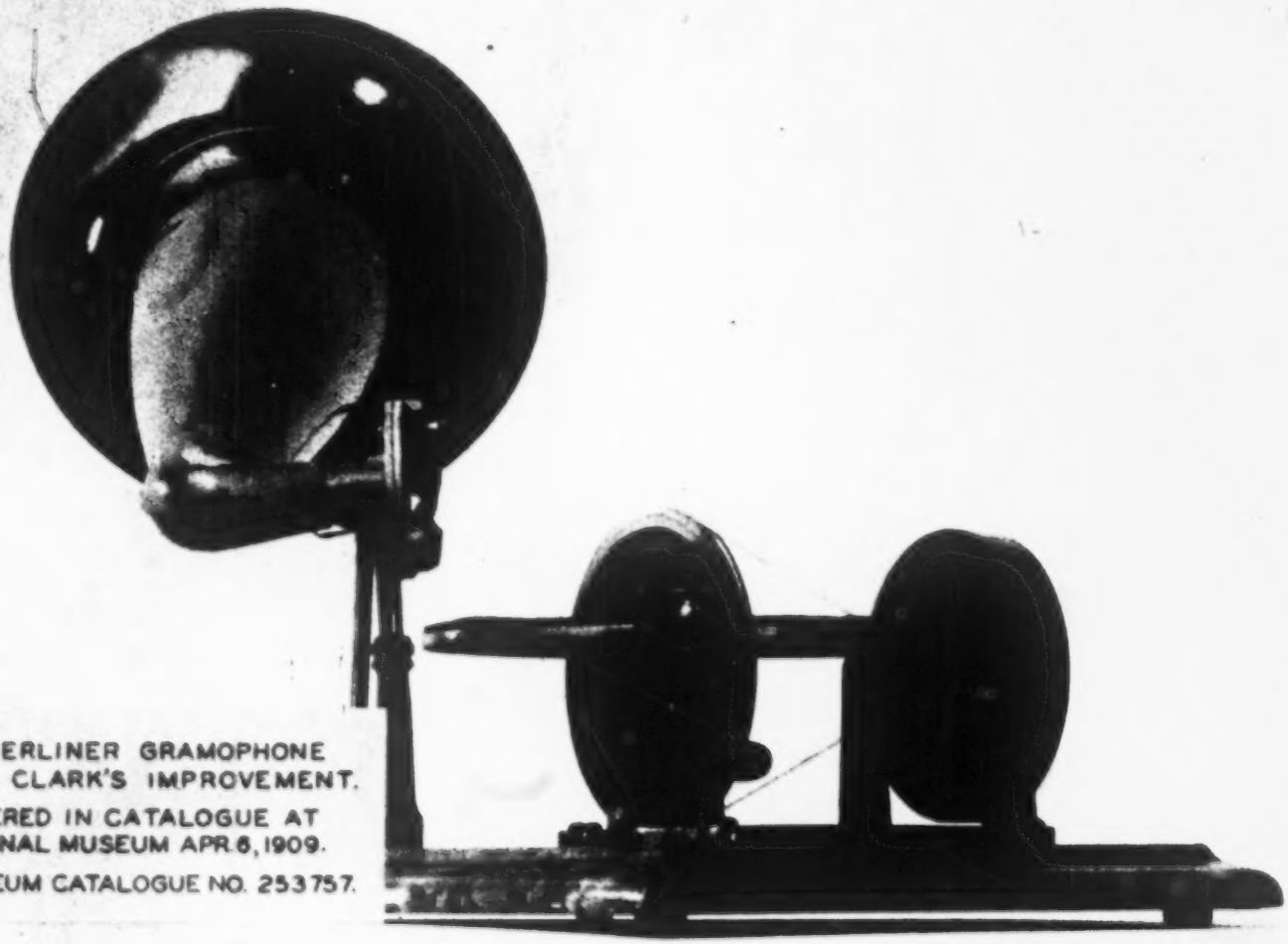
Attest: H. S. Bryant

Chief of Correspondence and Documents Division.

DEFENDANTS' EXHIBIT NO. 115-B.



U.S. DISTRICT COURT
M. D. PENN.
DEFT. EX.



BERLINER GRAMOPHONE
WITH CLARK'S IMPROVEMENT.
ENTERED IN CATALOGUE AT
NATIONAL MUSEUM APR. 6, 1909.
MUSEUM CATALOGUE NO. 253757.

U. S. DISTRICT COURT
M. D. PENN.
DFT. EX. 115 & 115C

DEFENDANTS' EXHIBIT NO. 115-C.

1587

DEFENDANTS' EXHIBIT NO. 115-D.

BERLINER GRAMOPHONE
WITH CLARK'S IMPROVEMENT.
ENTERED IN CATALOGUE AT
NATIONAL MUSEUM APR. 8, 1909.
MUSEUM CATALOGUE NO. 253757.

U. S. DISTRICT COURT
M. D. PENN. 115D
DEFT. EX. H5C

DEFENDANTS' EXHIBIT NO. 116-A.

116 A, B, C, D.

SMITHSONIAN INSTITUTION
UNITED STATES NATIONAL MUSEUM
WASHINGTON, D. C.

U. S. DISTRICT COURT
M. D. PENN.
DEFT. EX. 116A

S M I T H S O N I A N I N S T I T U T I O N

U N I T E D S T A T E S N A T I O N A L M U S E U M

TO ALL PERSONS TO WHOM THESE PRESENTS SHALL COME, GREETING:

THIS IS TO CERTIFY that the annexed photographs are a correct representation of a Berliner Gramophone entered in the United States National Museum, under Catalog No. 307204.

In testimony whereof I have hereunto set my hand and caused the seal of the Smithsonian Institution to be affixed, at the City of Washington, this 1st day of June in the year of our Lord one thousand nine hundred and thirty-three.

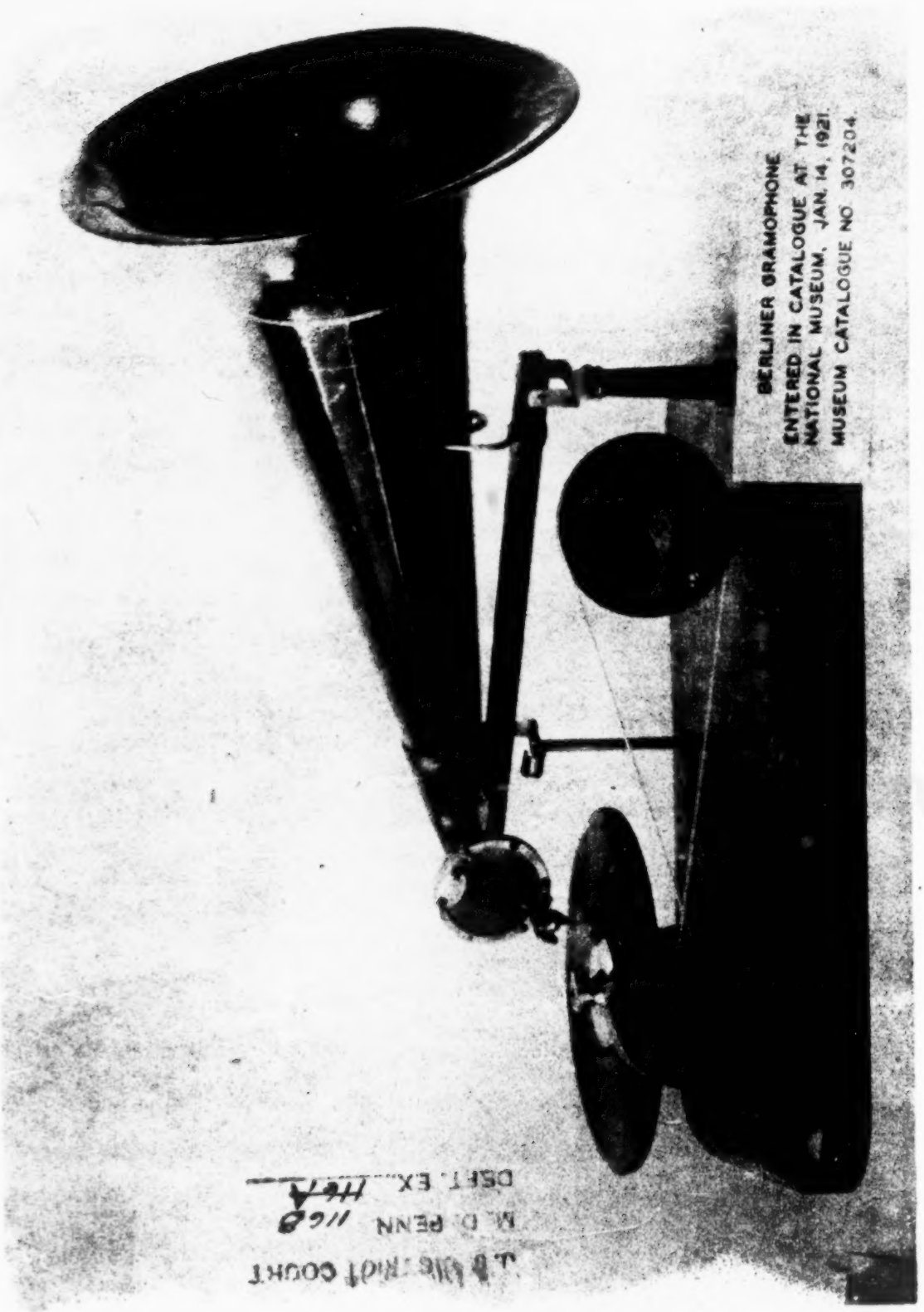
A. Wetmore

Assistant Secretary, Smithsonian Institution.

Attest: H. S. Bryant

Chief of Correspondence and Documents Division.

DEFENDANTS' EXHIBIT NO. 116-B.



DEFENDANTS' EXHIBIT NO. 116-C.

U. S. DISTRICT COURT
M. D. PENN. 116C
DEFT. EX. 116-B

BERLINER GRAMOPHONE
ENTERED IN CATALOGUE AT THE NATIONAL MUSEUM, JAN. 14, 1921.
MUSEUM CATALOGUE NO. 307204.

DEFENDANTS' EXHIBIT NO. 116-D.

DEFENDANTS' EXHIBIT NO. 117-A.

HTA, B, P, O.

SMITHSONIAN INSTITUTION

UNITED STATES NATIONAL MUSEUM

WASHINGTON, D.C.

U. S. DISTRICT COURT
M. D. PENN.
DEFT. EX. 117A

SMITHSONIAN INSTITUTION

UNITED STATES NATIONAL MUSEUM

TO ALL PERSONS TO WHOM THESE PRESENTS SHALL COME, GREETING:

THIS IS TO CERTIFY that the annexed photographs are a correct representation of a Bell - Tainter machine entered in the United States National Museum, under Catalog No. 287660.

In testimony whereof I have hereunto set my hand and caused the seal of the Smithsonian Institution to be affixed, at the City of Washington, this 1st day of June in the year of our Lord one thousand nine hundred and thirty-three.

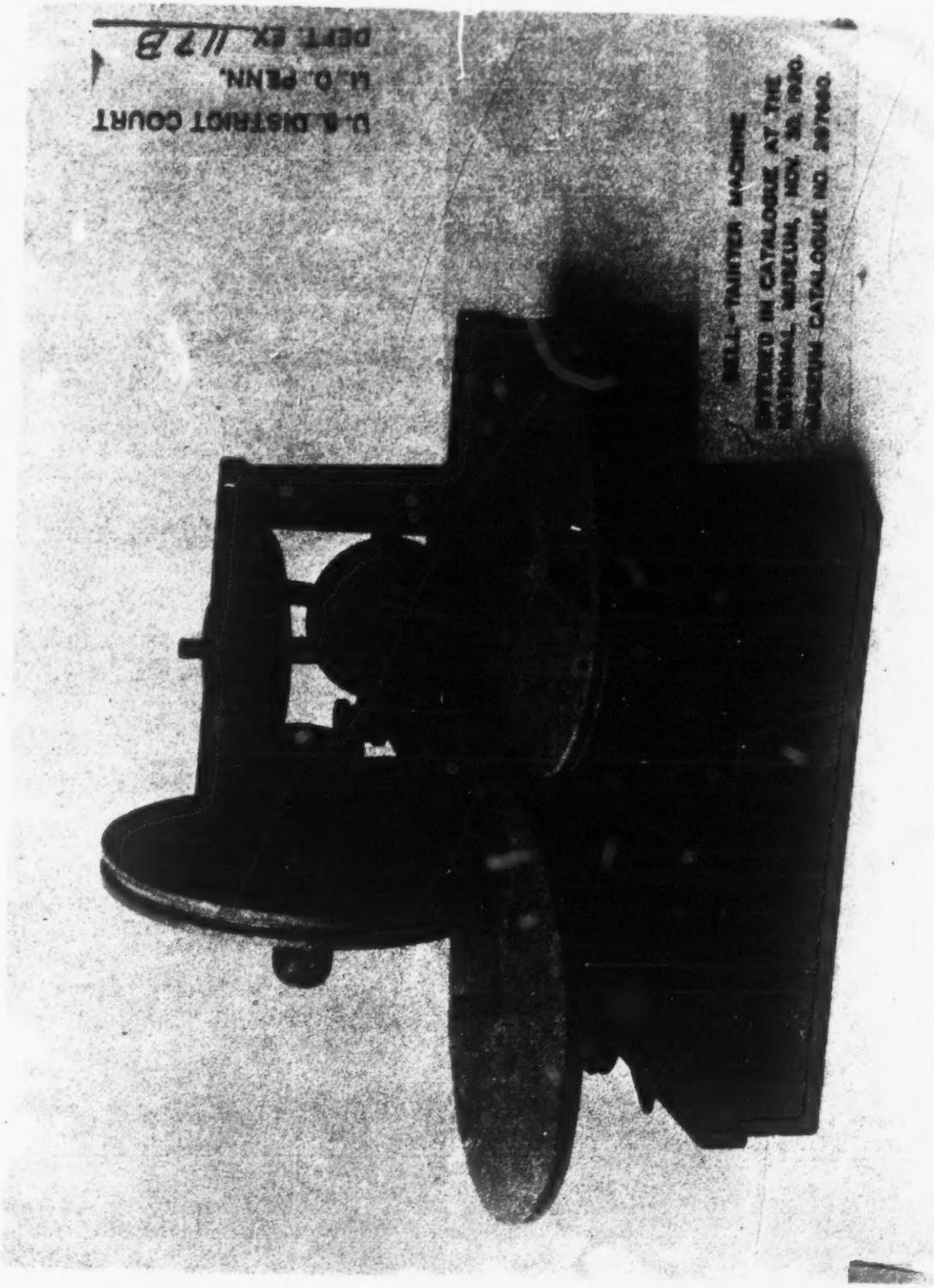
A. Wetmore

Assistant Secretary, Smithsonian Institution.

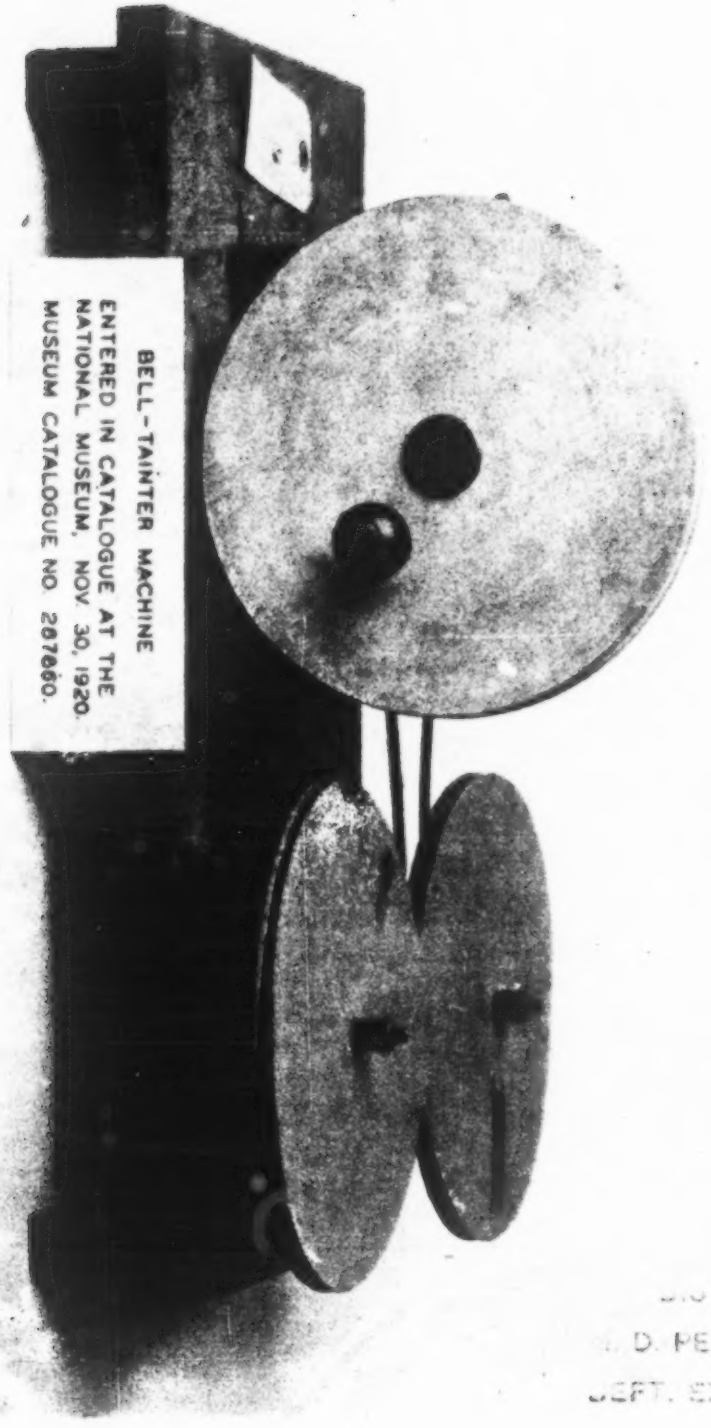
Attest: H. S. Bryant

Chief of Correspondence and Documents Division.

DEFENDANTS' EXHIBIT NO. 117-B.

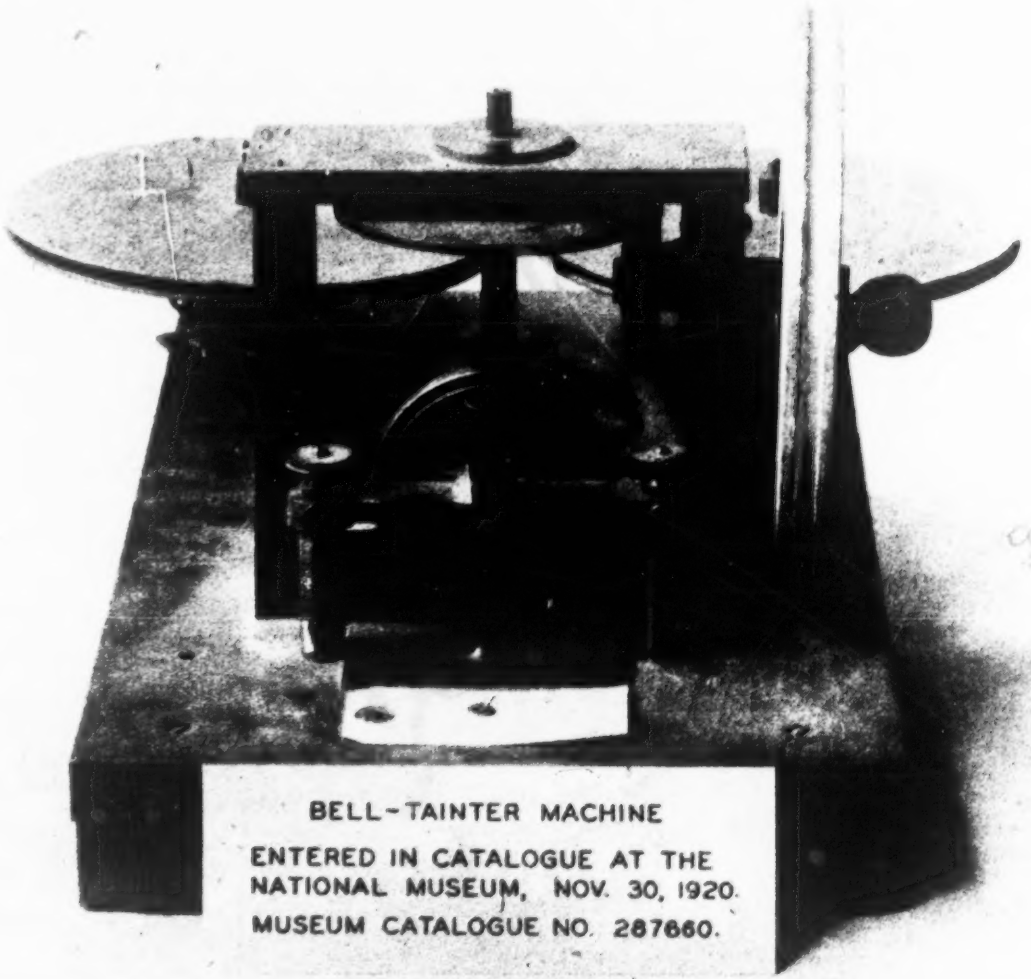


DEFENDANTS' EXHIBIT NO. 117-C.



DISTRICT COURT
E. D. PENN.
DEFT. EX. 117C

DEFENDANTS' EXHIBIT NO. 117-D.



BELL-TAINTER MACHINE

ENTERED IN CATALOGUE AT THE NATIONAL MUSEUM, NOV. 30, 1920.

MUSEUM CATALOGUE NO. 287660.

U. S. DISTRICT COURT

M. D. PENN.

DEFT. EX. 117 D

DEFENDANTS' EXHIBIT NO. 118-A.

118 A B C D

SMITHSONIAN INSTITUTION
UNITED STATES NATIONAL MUSEUM
WASHINGTON, D. C.

U. S. DISTRICT COURT
M. D. PENN.
DEFT. EX. 118A

SMITHSONIAN INSTITUTION

UNITED STATES NATIONAL MUSEUM

TO ALL PERSONS TO WHOM THESE PRESENTS SHALL COME, GREETING:

THIS IS TO CERTIFY that the annexed photographs are a correct representation of a Bell - Tainter machine entered in the United States National Museum, under Catalog No. 287653.

In testimony whereof I have hereunto set my hand and caused the seal of the Smithsonian Institution to be affixed, at the city of Washington, this 1st day of June in the year of our Lord one thousand nine hundred and thirty-three.

A. Wetmore

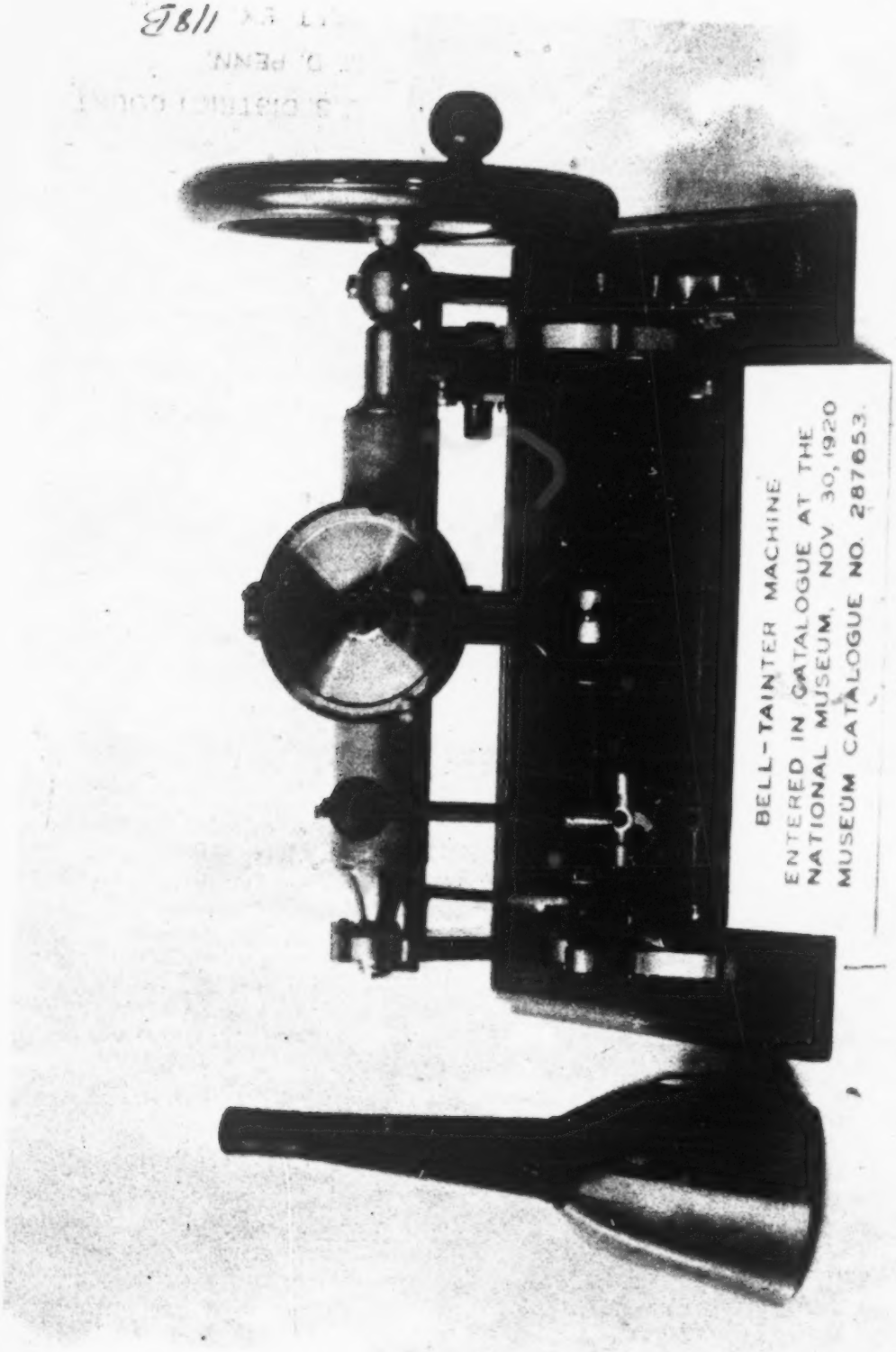
Assistant Secretary, Smithsonian Institution.

Attest: H. S. Bryant

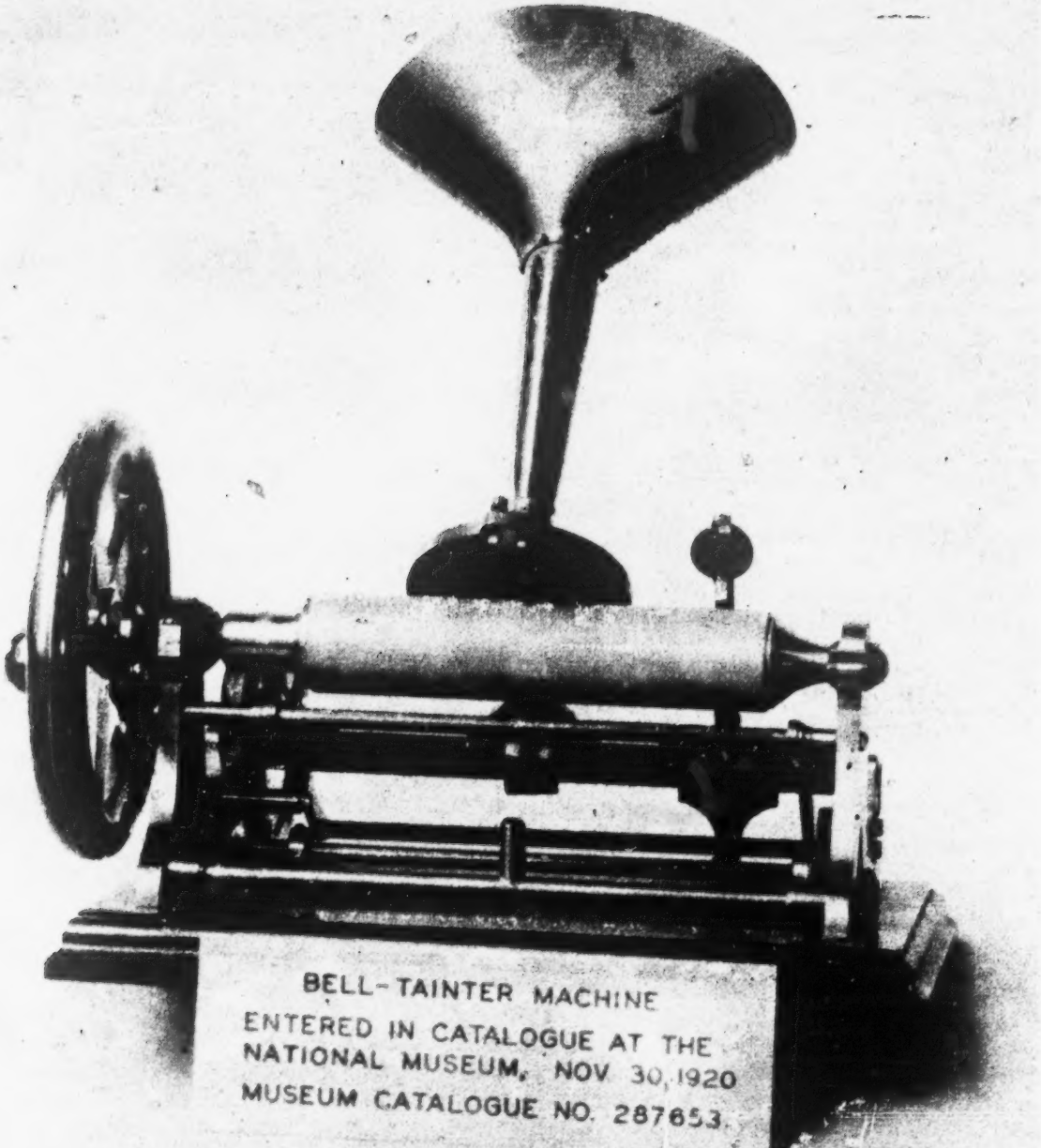
Chief of Correspondence and Documents Division.

1008

DEFENDANTS' EXHIBIT NO. 118-B.



DEFENDANTS' EXHIBIT NO. 118-C.



U.S. DIST. CT. COURT
PLAINTIFF'S EX. 118C

DEFENDANTS' EXHIBIT NO. 118-D.

DEFENDANTS' EXHIBIT NO. 119-A.

119 [illegible]

SMITHSONIAN INSTITUTION
UNITED STATES NATIONAL MUSEUM
WASHINGTON, D. C.

U. S. DISTRICT COURT
M. D. PENN.
DEFT. EX. 119A

SMITHSONIAN INSTITUTION

UNITED STATES NATIONAL MUSEUM

TO ALL PERSONS TO WHOM THESE PRESENTS SHALL COME, GREETING:

THIS IS TO CERTIFY that the annexed photostats are true copies of an original entry of accession No. 59,985 made in the National Museum Catalog in the Division of Engineering, under which accession No. 59,985 a pamphlet entitled "Instructions for the Management and Operation of Edison's Speaking Phonograph" was received by the United States National Museum under the Smithsonian Institution in Washington, D. C., and of an original Museum paper bearing accession No. 59,985 and describing the above identified pamphlet.

In testimony whereof I have hereunto set my hand and caused the seal of the Smithsonian Institution to be affixed, at the City of Washington, this 9th day of June in the year of our Lord one thousand nine hundred and thirty-three.

A Wetmore
Assistant Secretary
Smithsonian Institution

Attest: H. S. Bryant.
Chief of Correspondence and
Documents Division.

1743

DEFENDANTS' EXHIBIT NO. 119-B.

59985

DIVISION OF MECHANICAL TECHNOLOGY

U. S. DISTRICT COURT
M. D. PENN.
DEFT. EX. 119 B

Transportation No. 148,771. July 6, 1916.

Received July 5, 1916.

Edison Tin Foil Phonograph.

Wooden base, with drawer 17-1/2 inches long, 11-1/2 inches wide, 2-3/4 inches high; painted, cast iron base, 16-1/4 inches long, 10-1/4 inches wide, with upright brackets at each end, ~~which~~ support the main shaft of machine which is 28-1/2 inches long, 1-3/8 inches in diameter, with spiral thread 6-1/2 inches on one end; Heavy fly wheel, 11-5/8 inches in diameter; brass cylinder in center of shaft, 5-1/4 inches long, 5-1/2 inches in diameter with fine groove on outside; a sheet of tin foil is wrapped around the cylinder and held by a rod at one side which fits in a groove of the cylinder; the tin foil appears to be covered by a record made by the machine; hard rubber mouthpiece set in a metal frame, which is hinged at the bottom of the instrument, carrying a recording needle. The machine slides freely through its supports with mechanism at left and which can be set to make the shaft feed forward when it is revolved. Marked, "Experimental apparatus for illustrating the principle of Edison's speaking phonograph, Pat. Feb. 18th, 1878, No. 154, "Manufactured by S. Bergmann & Co., 404 Wooster St., New York."

Accompanying the machine is a paper entitled, "Edison's Speaking Phonograph," with instructions for operating, ~~which is~~ signed by F. H. Johnson, General Agent and Expert, The Edison Speaking Phonograph Company.

59985

Fiber trumpet with rubber tip intended for use to intensify the sound of the machine.

In the drawer of the base there is an oil can and several small pieces of apparatus.

Geo. C. Maynard

Curator.

U. S. DISTRICT COURT
M. D. PENN.
DEFT EX. 119C

DEFENDANTS' EXHIBIT NO. 119-C.

U. S. DISTRICT COURT
M. D. PENN.
DEF. EX 119D

Catalogue No.	Accession No.	Original No.	Name	Sex	Locality.	When Collected	Received from—	Collected by—	When Entered	No. of Spec.	Remarks
1916-1917											
291,276	59,955	1	Edison tin-foil phonograph		Talking		Gift of Thomas A. Edison				Acc. July 10, 1916
291,840	60,118	1	Life Member Natl. Highways Assn.				Returned to Dr. Bell May 23, 1922	Lent by Dr. Alexander G. Bell	1		August 14, 1916
291,8-28	-	1	Diffl. Royal Inst. Dec. 5, 1910				Returned to Dr. Bell May 23, 1922	"	1	"	" "
291,843	-	1	Invitation to lecture, Salem, 1855				Returned to Dr. Bell May 23, 1922	"	1	"	" "
291,844	-	1	Invitation to lecture New York, 1877				Returned to Dr. Bell May 23, 1922	"	1	"	" "
291,845	-	1	Invitation to lecture, Boston, 1877				Returned to Dr. Bell May 23, 1922	"	1	"	" "
291,846	-	1	Invitation from Empress of Japan, 1887				Returned to Dr. Bell May 23, 1922	"	1	"	" "
291,847	-	1	Names of Attendants, Kyoto, Japan, 1898						1		
291,850	60,152	1	Ballard Target rifle					Dr. Milton Farrow			19, 1916
292,024	60,200	1	American Clock				Purchased ($2.00)	Mrs Emil E Weise	1		September 6, 1916
292,196	60,234	1	Watch movement				Gift of Abraham Burnstine		1		" 14, 1916
292,137	"	1	Watch movement Paris, 1855				"	"	1	"	" "
292,138	-	1	Watch movement Cameron Ames & Co				"	"	1	"	" "
292,139	"	1	Watch movement #2594137				"	"	1	"	" "
292,140	"	1	Watch movement, Baillard patent				"	"	1	"	" "
292,141	"	1	Watch movement, Elgin				"	"	1	"	" "
292,142	"	1	Pocket dagger "Weil & Fink"				"	"	1	"	" "
292,164	60,273	1	Cooper revolver				Lent by E. J. Craig		1	"	" 21, 1916
292,150	60,295	1	Lot of lead bullets, about 300				Gift of Mrs. Julian James			"	" 23, 1916
292,396	60,361	1	Burroughs Adding Machine Co. No. 54 returned to donor, Oct. 14, 1924				Lent by Burroughs Adding Machine Co.			"	October 9, 1916
292,397	-	1	" " No. 3128 53.				Returned to Burroughs Adding Machine Co. Oct. 14, 1924	"	"	"	" " "
292,436	60,463	1	Bacon revolver				Gift of T. C. Harris		1	Acc. Transferred to Division of Textiles Jan. 1917	Nov. 6, 1916
292,772	60,532	1	Original Howe Sewing Machine, 1845				Lent by Elias Howe J. Stockwell			"	" 23, 1916
293,051	60,603	1	Silver watch. Lutz Fires.				Gift of Nathan Parkins.			"	Dec. 15, 1916.
292,232	60,640	1	Fish Com. Schooner Grampus				Transfer, Bureau of Fisheries		1	"	" 28 "

DEFENDANTS' EXHIBIT NO. 120-A.

SMITHSONIAN INSTITUTION
UNITED STATES NATIONAL MUSEUM
WASHINGTON, D. C.

120 F (2)
DISTRICT COURT
E. PENN.
DEF. EX. 120 A

SMITHSONIAN INSTITUTION

UNITED STATES NATIONAL MUSEUM

TO ALL PERSONS TO WHOM THESE PRESENTS SHALL COME, GREETING:

THIS IS TO CERTIFY that the annexed photostats are a true copy of a pamphlet entitled "Instructions for the Management and Operation of Edison's Speaking Phonograph" entered in the United States National Museum, under the Smithsonian Institution in Washington, D. C., under accession number 59,985.

In testimony whereof I have hereunto set my hand and caused the seal of the Smithsonian Institution to be affixed, at the City of Washington, this 9th day of June in the year of our Lord one thousand nine hundred and thirty-three.

A. Wetmore
Assistant Secretary
Smithsonian Institution.

Attest: H. S. Bryant
Chief of Correspondence and
Documents Division.

DEFENDANTS' EXHIBIT NO. 120-B.

INSTRUCTIONS

FOR THE

Management and Operation

OF

EDISON'S

SPEAKING PHONOGRAPH

PHILADELPHIA:
BURNS & PETERSIDGE, STEAM-POWER BOOK AND JOB PRINTERS, 304 CHESTNUT STREET.
SUCCESSORS TO INQUIRER PRINTING HOUSE.
1878.

EDISON'S

SPEAKING PHONOGRAPH.

DESCRIPTION AND INSTRUCTIONS FOR OPERATING.

The adaptation of this wonderful discovery to the practical uses of commerce and social life not having, as yet, been completed, in all its mechanical details, this company is prepared to offer to the public only that design or form of apparatus which has been found best adapted to its exhibition as a novelty.

Of this class of Phonographs, we make two styles: One for the general purpose of exhibition, and one for the drawing room and scientist's sanctum.

The mechanism of each is precisely the same. The performance differs only in these particulars:

No. 1. The exhibition instrument has a cylinder grooved with twenty-four threads per inch.

No. 2. The drawing room instrument has a cylinder grooved with forty threads per inch.

This gives to No. 2, the advantage of nearly double the recording surface on a cylinder of the same size. It also adds a trifle to the distinctness of the articulation, and approximates more nearly the quality of the voice.

In point of volume of sound, and in general effectiveness in illustrating the working of the apparatus to an assemblage of any considerable number of people, there is no appreciable difference between them.

No. 1. Is all of iron, except the cylinder, which is of brass. The iron work is all neatly japanned and ornamented. It is mounted upon a neat white wood box, in which is a drawer for the small tools and supplies which accompany each machine.

No. 2. Is all of brass, hand-filed and beautifully finished throughout. The fly-wheel, base, etc. being of brass, the instrument is given a rich appearance. It is mounted upon a handsome rosewood and inlaid box, with drawer for tools.

Each instrument is furnished with the following list of Foil, tools, etc:

1. This Letter of Instructions.
2. 5 pounds of special made Record Foil.
3. 1 Oil Stone.
4. 1 Oil Can.
5. 1 Screw-Driver.
6. 1 Centering Pin.
7. 1 Funnel.
8. 1 piece Rubber Cushion.
9. 1 " " for wedge.
10. 1 " Wax Cement.
11. 6 Prepared Stylus'.

Each instrument is packed for shipment in a neatly made box, of 1½ inch stuff, water tight, and with heavy iron handles on the ends. The instrument is so braced in this box as to render its damage in transit well nigh impossible. The outside dimensions of this box, are

Length—2 feet 10 inches.
Width—1 foot 2 inches.
Depth—1 foot 2 inches.
Total weight of instrument and box, 175 pounds.

When properly adjusted the Phonograph will speak loud enough to be distinctly heard by an audience of from three to five thousand people. It is the *character* of the sound that makes this possible, apparently it is barely a fourth as loud as the original voice, yet its "voice" may be heard at an almost equal distance.

Price of No. 1 Instrument, $ 100.-
" " 1½ " $ 150.-

Terms, part payment in advance, balance C. O. D. No discounts.

No Phonographs loaned or rented.

The Record Foil especially manufactured for the Phonograph, may be had of S. Bergmann & Co., 104 Wooster St., New York. There are thirty sheets to the pound.

It is put up only in 5, 10 and 20 pound boxes. Not more than 20 pounds can be shipped safely in *one* box.

Price, 45 cents per pound. Boxing, 25 cents.

Terms, one-half cash in advance, and balance C. O. D.

Extra Stylus' and Diaphragms may also be had of the same parties.

Price of Stylus', 15 cents each.

" Diaphragms, 10 cents each.

It is very rare for a Diaphragm to give out : in point of fact they improve by use, and are only damaged by carelessness or accident.

No other parts ever require renewal.

DESCRIPTION.

Explanation of figures in accompanying drawings.

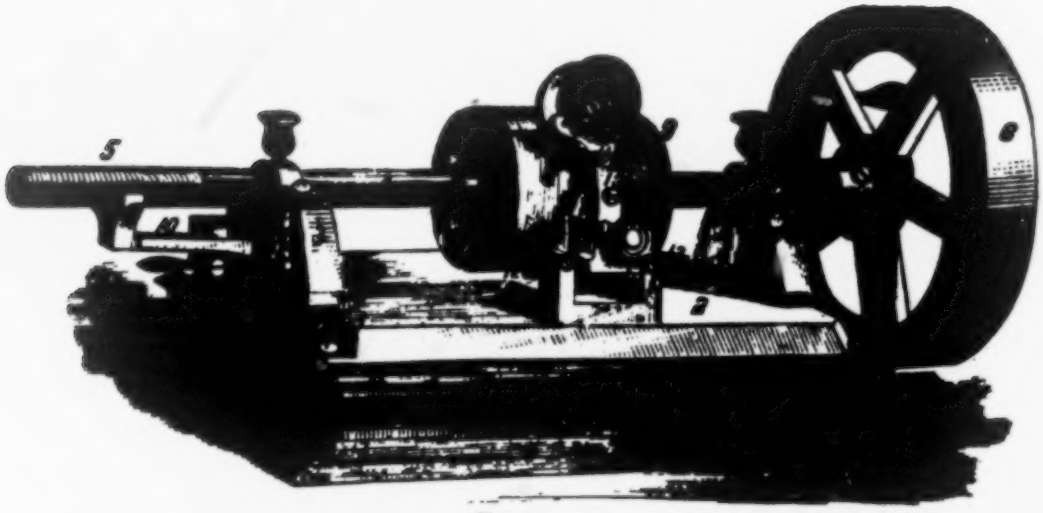


FIG. 1.

1. A box to elevate the instrument to accommodate the fly-wheel which is higher than the instrument proper. This box is furnished with a drawer for tools, etc.

2. The framework of the machine.

3. Two smooth bearings for the shaft.

4. Cast-steel shaft carrying the cylinder.

5. A screw thread upon the end of the shaft, to give the instrument a gradual lateral motion whilst being rotated.

6. Heavy fly-wheel, to give a uniform motion. (Very important.)

7. The cylinder upon which the foil is placed to *receive* and *reproduce* the sound.

8. A screw thread or groove corresponding to that upon the shaft, the object of which is to remove all *support* from under the *foil* at the *precise point where the stylus presses upon it.* Thus permitting the foil to be more readily indented by the stylus than would be possible if the surface underneath the foil was solid.

9. A slot cut across the cylinder to receive the two ends of the foil, and a steel and rubber rod or wedge, which is pressed in on the foil to hold it

10. An adjustable arm working upon centres, held downward by a flat steel spring, and forced upward by a cam movement, the function of which is to hold a half nut either *in* or *out* of the thread upon the shaft, as it may be desired to carry the cylinder forward with the nut, or slip it back free of it.

11. An upright arm for holding the mouth-piece, diaphragm and stylus combination in proper position.

12. Centre screws for moving the mouth-piece to the right or left, as may be required to bring the stylus to a position *exactly in the centre of a groove.*

13. A screw for regulating the depth of the groove made in the record foil by the stylus.

14. A cam (adjustable), to lock the upright arm in position, while a record is being made or reproduced.

Figure 2.

FIG. 2.

1. Diaphragm of mica—a thin plate which vibrates in unison with the voice, or other sounds thrown upon it.

2. A stylus or needle-point for recording the movements of the diaphragm upon the foil, and for retraversing the record thus made, and giving back to the diaphragm its original vibratory movement, and consequently reproducing the sounds.

3. A cushion made of rubber tubing, the function of which is to destroy the too metallic sound which is had from direct metallic contact between the stylus and plate.

4. A steel spring to hold the stylus rigidly in position, weakened near the base so as not to exert any pressure upon the diaphragm.

5. Wax—so placed as to hold the cushion very firmly to the plate, and also the stylus spring firmly to the cushion, (exceedingly important).

Figure 3.

FIG. 3.

1. A hard rubber mouth-piece, into which the vocal or other sounds are thrown.

2. A cushion of rubber tubing, placed across the orifice in the mouth-piece, so that by screwing the mouth-piece into its frame, a pressure of this cushion is had upon the inside of the diaphragm, thus enabling any desired tension to be obtained upon the diaphragm—the end to be obtained being more perfect articulation, and a more natural tone.

Fig. 4.

A funnel for increasing the volume of sound in the reproduction.

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INSTRUCTIONS FOR OPERATING.

1st. *To put the Foil on.*

Keep the foil perfectly free from kinks, draw it firmly around the cylinder, so that when fastened it is perfectly smooth and free from buckles or looseness in every part. Let the under edge pass over the slot just reaching the opposite edge, but not passing it, press the wedge into the slot with the ends of the fingers, deep enough to prevent the stylus from touching it.

2. *The Dampener.* (Fig. 3.)

To dampen the vibrations of the diaphragm, turn the mouth-piece to the right. This causes the rubber tubing to put an increased tension upon the plate. The most ready means of determining the proper tension is to sound a strong note into the mouth-piece while holding the finger lightly on the stylus. When the tension is slack the stylus will prick the finger very decidedly. Keep turning the mouth-piece to the right by small degrees, until the movement of the stylus is perceptibly diminished. It is then ready for use. If it is found upon trial to be dampened too much, it may be readily adjusted to the proper tension by experimenting with the voice.

3. *The Stylus Adjustment.* (Fig. 2.)

The first thing to do in adjusting the stylus is to turn the regulating screw (Fig. 1, No. 13) to the right, enough to prevent the stylus from touching the foil, when the mouth-piece is pressed forward into position; then turn the regulating screw to the left gradually, until it describes a slight line on the foil. Now see to the adjustment of the stylus *into the centre of the grooves* upon the cylinder. To do this, take the pointed iron pin (called a "centre pin"), press the pointed end upon the line described by the stylus. The centre pin will cause the foil to be depressed into the groove nearest the line. You will then be able to see how near the stylus is to its proper position. If too far to the left, take the blunt end of the centre pin and turn the centre screws (Fig. 1, No. 12) to the right gradually, until the line made by the stylus passes directly through the centre of that made by the centre pin, taking care always to keep sufficient tension upon the upright arm, by tightening the centre screws, to enable it to just support the weight of the upright at any angle it may be placed. This is to prevent any side movement of the stylus. Now, the regulating screw may be turned to the left until a groove is made of the proper depth, which is always shown by the sheet of record foil accompanying the instrument; say about 1-32 of an inch deep.

Care must be observed in *locking the upright* into position. It should always be locked *very rigidly* to prevent the mouth-piece from being forced forward when the lips press upon it in speaking, and to ensure its going sufficiently forward at all times to cause the stylus to make the proper depth of groove.

This locking cam (Fig. 1, No. 14) has two adjustments. It is itself a screw, and may be turned further in or out, as may be required to bring the steel lips into the angle slots; and the slots themselves being made at an angle, impose a grip upon the lips as they are pressed into them.

In effecting the adjustment of the stylus, as well also as at all times when using the instrument, observe carefully this

CAUTION:

Never turn the instrument backward, or permit it to drop backward slightly, by checking its momentum with the handle. The surest means of preventing this is to invariably stop the instrument, by placing the hand upon the balance wheel instead of the handle.

Never remove the carrying nut from the shaft thread until the stylus has been withdrawn from the foil; otherwise, the stylus is drawn *across* the grooves and is liable to be broken.

4. *The Movement of the Cylinder.*

The best average rate of speed at which to rotate the cylinder is about sixty revolutions per minute. To reproduce the sounds in as near as possible their original tone, precisely the same speed must be had in the reproduction as in the recording. A uniform speed is very important, especially in the reproduction of all musical tones.

The reversal of the cylinder is effected by releasing the carrying nut (Fig. 1, No. 10), and slipping the shaft to the right, through the smooth bearings, all the while keeping up a *forward* rotation of the cylinder. This maintenance of the rotary movement of the cylinder while the nut is being forced *into* or *withdrawn* from the thread, is important to facilitate the operation of the nut, and to prevent the nut from being locked *on top of the thread* instead of into it.

5. *To effect the best Record.*

To speak to the instrument with the greatest effect, the lips should be placed as far into the mouth-piece as possible, consistent with a clear and distinct utterance of the words. The best tones are the deep, strong chest tones. The best in *quality* is the fine soprano of a lady or child.

6. *Reproduction of the Sounds.*

To reproduce any sounds which have been recorded, return the stylus to the original starting point, by moving the cylinder to

the right, as provided in Article 4. Lock the stylus again in position, place the funnel (Fig. 4) on the mouth-piece, and rotate the cylinder precisely as when making the record.

7. *Renewal, fixing and shape of Stylus.*

This is by far the most important of all the details of the Phonograph. The volume of sound and the perfection of the articulation depend almost wholly on the shape and position of the stylus.

Fig. 2, shows the proper position. The diaphragm, No. 1, should be perfectly flat and free from buckles.

The stylus, No. 2, should be shaped as shown in the drawing, like a chisel with a short bevel, the bevel resting upon the foil parallel with the cylinder.

No. 3, a rubber cushion made of tubing about one-quarter of an inch long. The steel spring, (No. 4), which holds the stylus, should be clamped in the holder, so as to permit the top of it to just reach the centre of the cushion, which cushion is placed exactly in the centre of the plate; this brings the stylus itself, a trifle, say one-sixteenth of an inch *below the centre* of the plate, which has proven to be the most effective position. In cementing this cushion to the plate, and the spring to the cushion, great care must be had to obtain *solidity of contact.* The best method is to place a small piece of wax about half the size of a pea, on the plate, touch it with a heated screw-driver or small flat piece of metal, holding the cushion on with the thumb lightly at first, until the wax has melted and run under the cushion, then putting some pressnre on it and causing the remaining wax to form a little bridge between the cushion and the plate, (avoid getting the wax on the upper section of the cushion, as it must have a certain degree of elasticity across its centre), hold the cushion down until the wax has cooled, then repeat the operation on the other side of the cushion. It will be found more convenient to do this by taking the mouth-piece from the upright, and laying it on the table. When the cushion has been thus placed it should be *flat on the bottom.*

To fasten the spring to the cushion, take a piece of wax about one-sixteenth of an inch in diameter, insert it between the spring and the cushion, and hold the heated metal piece on the top end of the spring until the wax has thoroughly melted, pressing it down firmly all the while—as soon as the wax is thoroughly melted, substitute a cool piece for the heated piece, to hold it down until the wax

This locking cam (Fig. 1, No. 14) has two adjustments. It is itself a screw, and may be turned further in or out, as may be required to bring the steel lips into the angle slots; and the slots themselves being made at an angle, impose a grip upon the lips as they are pressed into them.

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6. *Reproduction of the Sounds.*

To reproduce any sounds which have been recorded, return the stylus to the original starting point, by moving the cylinder to

Again cylinder with pointed ear piece

Tried to feature the use of the fly-wheel 50 years ago. Rejected as "a mere double use of a fly-wheel as ordinarily used with machinery for giving a uniform motion." 1916-1917 Adrian Rolling Horse with Phonofilm

Desirability of uniform motive power whether sound is recorded on cylinder, or on disc or on elongated carrier such as a film. Professor, this volume, 1346

the right, as provided in Article 4. Lock the stylus again in position, place the funnel (Fig. 4) on the mouth-piece, and rotate the cylinder precisely as when making the record.

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has thoroughly set, then press the spring down hard with the finger, three or four times, to restore elasticity to the cushion, taking care not to loosen the spring from the cushion, or the cushion from the diaphragm.

If at any time the instrument appears to be less effective than usual, examine the cement between the spring and the cushion, and if not very firmly held, reset it, and, nine times out of ten, the result will be beneficial.

It has been thought well to be thus explicit and elaborate in these instructions, because of the fact that few have ever seen the Phonograph, and have no data by which to judge as to whether or no they obtain the full capacity of the instrument. If these instructions are carefully followed, the most perfect novice will be able to obtain the full capabilities of the Phonograph.

A good strong voice and a distinct utterance are the requisite qualifications of a good operator.

The Edison Speaking Phonograph Co.

66 READE STREET, NEW YORK.

REMOVED TO 17th ST. & 4th AVE.

E. H. JOHNSON, *Secretary.*

DEFENDANTS' EXHIBIT NO. 121.

Separate Film Gate of Defendants' Machine PS1.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 122.

Separate Flywheel Assembly of Defendants' Machine PS1.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 123.

Separate Film Gate of Defendants' Machine PS16.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 124.

Separate Flywheel of Defendants' Machine PS16.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 125.

Separate Guide Roller of Defendants' Machines PS1 and PS16.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 126.

File History and Contents of Engl, Massolle and Vogt, United States Patent No. 1,590,185.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 127.

VARIETY - Tuesday, December 1, 1931 - Page 25

U. S. DISTRICT COURT 127
PENN.
T. EX. 127

AMERICAN TRI-ERGON CORPORATION

10 WEST 47th STREET
NEW YORK CITY

WILLIAM FOX
President

Notice to the Sound Picture Industry

PRESENT DAY sound pictures utilizing photographic film sound records are essentially dependent upon several early and important inventions of Messrs. Engl. Vogt, and Massolle. These inventors are German scientists who did pioneer work in this field, and were the first to produce and publicly exhibit successful film sound records.

The attention of the sound picture industry is directed to the following U. S. patents covering certain of these inventions now owned by American Tri-Ergon Corporation.

1. *Patent No. 1,713,726, Vogt, et al., granted May 21, 1929. This is the patent popularly known as the "flywheel patent" and it relates to certain methods and apparatus for uniformly moving the sound record film under the control of inertia, either in recording or reproducing machines utilizing sound controlled light in translating the sound to or from the film. This patent also relates to the photoelectric cell when used with such reproducing apparatus, as is now the general practice.*

2. *Patent No. 1,825,598, Vogt, et al., granted September 29, 1931. This patent relates to the process for producing combined sound and picture film by photographing the sound and pictures on separate films so that they may be developed separately, and then printing both records side by side on a single film. This process, as you know, is very extensively used in the industry. This patent was recently granted after prolonged litigation on priority with Dr. Lee De Forest, in which the Court affirmed the Patent Office decisions in our favor.*

Attention is invited to the patents themselves for a fuller understanding of their scope.

Applications for other early and important inventions are still pending.

Producers, exhibitors, and manufacturers utilizing any of the inventions of said patents are hereby notified and warned that they will be held liable for all profits made or damages arising from their infringements of said patents.

Infringement suits have recently been instituted under these patents against representative concerns in the industry. Further suits will be brought, if necessary, against infringing film producers and theatre operators and against manufacturers of infringing apparatus, for the purpose of restraining all unlicensed use of these inventions.

Licenses under these patents may be acquired under proper conditions. The object of this notice is to acquaint the industry with the situation in order that further liability for unlicensed use of the inventions may be avoided.

AMERICAN TRI-ERGON CORPORATION

DEFENDANTS' EXHIBIT NO. 128.

NO. 128.

U. S. DISTRICT COURT

M. D. PENN.

Der sprechende Film nach dem Tri-Ergon-Verfahren 128

Von Hans Vogt, Berlin-Wilmersdorf.

Es wird über ein Verfahren zur Herstellung „sprechender Filme" berichtet, bei dem ein neuartiges trägheitsloses Mikrophon, frequenzunabhängig arbeitende Verstärker, eine trägheitslose Lichtquelle für die Aufnahme, eine Alkalimetallzelle und neuartige elektrostatische Lautsprecher für die gleichzeitige Wiedergabe des Tones mit dem kinematographischen Bild verwendet werden.

Das erstrebenswerte Ziel, eine Einrichtung zu schaffen, die es gestattet, das Sehbare und Hörbare der Lebensvorgänge gleichzeitig zu erfassen und gleichzeitig wiederzugeben, konnte, wie die Entwicklung der letzten Jahrzehnte lehrte, durch einfache Verbindung des Films mit dem Grammophon nicht erreicht werden. Keine der sinnreichen mechanischen Synchronisiereinrichtungen konnte den völlig gleichmäßigen Ablauf der zusammengehörigen Film- und Phonogrammstellen, der für den Eindruck der Zusammengehörigkeit Voraussetzung ist, auf die Dauer gewährleisten; genügt doch schon in der zeitlichen Abfolge ein Unterschied von $^1/_{20}$ Sekunde, um beim Beobachter den Eindruck der sprechenden Photographie zu zerstören.

Erst durch die Wiederaufnahme des seit Anfang dieses Jahrhunderts bekannten Verfahrens, die Schallwellen photographisch festzuhalten, wodurch es möglich wurde, Phonogramm und Reihenbild auf einen gemeinsamen stofflichen Träger, den Zelluloidfilm, aufzubringen und das Synchronitätsproblem zu umgehen, ferner durch die Schaffung neuer technischer Mittel für die Aufnahme und Wiedergabe von Schallwellen wurde jene Lösung, über die ich im folgenden berichten will, und die bereits bei längeren Vorführungsreihen ihre praktische Brauchbarkeit bewiesen hat, möglich.

Die erforderlichen Arbeiten wurden von Joseph Massolle, Dr. Jo Engl und dem Verfasser in der Zeit von 1918 bis 1924 in Berlin unter gleicher Beteiligung durchgeführt. Diese Erfindergemeinschaft, die sich auf Anregung des Verfassers zur gemeinsamen Bearbeitung dieser Aufgabe bildete, hat sich das Kennwort „Tri-Ergon" beigelegt. Mit diesem Wort wurden auch die Ergebnisse der gemeinsamen Tätigkeit benannt, ebenso das die wirtschaftliche Verwertung dieser Erfindungen betreibende Unternehmen[1]).

Abb. 1. Kathodophon.

Die Gesamtaufgabe.

Unter der Voraussetzung, daß nur die photographische Aufschreibung, die es gestattet, Phonogramme neben den Reihenbildern des üblichen Films mit den bekannten photographischen Mitteln zu erzielen, Aussicht hat, den Bedingungen der Praxis völlig zu genügen, ergabe sich etwa die folgende technische Gesamtaufgabe:

Die von der aufzunehmenden Handlung ausgehenden Schallwellen wären aus Gründen der erforderlichen Verstärkung zunächst zur Änderung eines elektrischen Stromes zu benutzen. Der letztere hätte Lichtänderungen zu erzeugen, die zusammen mit dem Bildvorgang photographisch festzuhalten, zu vervielfältigen und wiederzugeben wären. Bei der Wiedergabe würde mittels des durchleuchteten photographischen Schallwellenbildes ein veränderlicher elektrischer Strom herzustellen sein, den man zur Betätigung der eigentlichen Schallwiedergabemittel benutzen müßte. Bei allen diesen Umformungen müßte Bedingung sein, daß die Charakteristik der Schallschwingungen bei den verschiedenen Umformungen keine Verzerrung erleidet. Schließlich hätte die wiederzugebende Schallmenge der bei der Aufnahme vorhandenen annähernd zu entsprechen.

Die Gesamtaufgabe wäre in eine Reihe Einzelaufgaben zu zerlegen, die samt den Lösungen, die gefunden wurden, nunmehr beschrieben werden sollen.

Die Teilaufgaben und ihre Lösungen.

1. Umformung von Schalldruckschwankungen in elektrische Schwankungen.

Alle praktisch vorkommenden Schallschwingungen von etwa 50 bis etwa 15 000 Per./s müssen innerhalb der durch die Handlung gegebenen Entfernungen während der kinematographischen Aufnahme aufgenommen, d. h. in Änderungen eines elektrischen Stromes „umgewandelt" werden.

Die Einrichtungen, die zu Beginn der Arbeiten des Tri-Ergon angewendet wurden, waren die bekannten Kohlekörnermikrophone. Deren Nachteile: Hervortreten von Resonanzlagen ihrer schwingenden Teile, Geräusche, verursacht durch Umlagerung ihres Füllstoffes, machten sie für den beabsichtigten Zweck unbrauchbar. Es erschien aussichtslos, mit ihnen die erforderliche Reinheit zu erzielen. Die Aufgabe, ein qualitativ wertvolles Mikrophon ohne schwingende materielle Teile zu schaffen, das die Schalldruckschwankungen vollkommen proportional in Schwankungen eines elektrischen Stromes übertrug, wurde durch die Erfindung des Kathodophons, einer schallempfindlichen Glimmlichtentladung, gelöst, Abb. 1.

Diese neue, vom Tri-Ergon angegebene Anordnung[2]) beruht auf der Beobachtung, daß eine winzige Glimmentladung, vorteilhaft unter Benutzung ionisierender Mittel (Oxyde der Erdalkaligruppe) an einer dem Luftsauerstoff gegenüber sich neutral verhaltenden Glühkathode in der freien Atmosphäre erzeugt, unter gewissen Bedingungen ihren Widerstand unter dem Einfluß der Schallwellen ändert.

Abb. 2 zeigt schematisch die Schaltung einer derartigen schallempfindlichen Entladungsstrecke. In ihr

[1]) Tri Ergon A.-G., Zürich.

[2]) DRP Nr. 350 569, 351 955, 351 956.

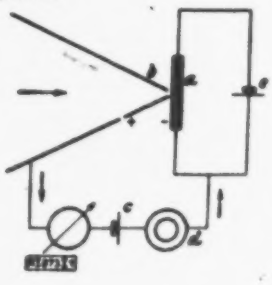

Abb. 2. Schaltung des Kathodophons.

a Kathode
b Anode
c Anodenbatterie
d Hörgerät
e Heizbatterie

ist *a* eine elektrisch durch die Batterie *e* geheizte, mit Kalziumoxyd versehene feuerfeste Kathode. Die Anode *b* ist zur Sammlung des Schalles als Trichter ausgebildet, dessen gekappte offene Spitze der Kathode mit einem Zwischenraum von etwa $^1/_{10}$ mm gegenübersteht. Unter dem Einflusse des von der Anodenbatterie *c* zwischen *a* und *b* erzeugten elektrischen Feldes von etwa 300 V verlassen negativ geladene Teilchen die Kathode und wandern infolge des durch die freie Atmosphäre bedingten hohen Druckes mit verhältnismäßig kleiner Geschwindigkeit zur Anode. Der Schall, durch die trichterförmig ausgebildete Anode in den Entladungsweg eingeführt, beeinflußt nun den Emissionsvorgang in einer theoretisch noch nicht restlos geklärten Weise, so daß sich der Widerstand der Entladungsstrecke bzw. der Strom im Anodenkreis unter bestimmten technischen Voraussetzungen verhältnisgleich der Stärke, der Frequenz und der Charakteristik des eingeführten Schalles ändert, einen schallgetreuen elektrischen Wechselstrom hervorruft, der durch das in den Anodenkreis eingeschaltete Hörgerät *d* wieder als Schall geprüft werden kann. Die Empfindlichkeit dieser Einrichtung wird beträchtlich gesteigert, wenn die Anodenspannung so hoch gewählt wird, daß in der Entladungsstrecke Stoßionisation auftritt[1]). Dieser Effekt ist aus Abb. 3, die die Abhängigkeit des Anodenstromes von der am Kathodophon liegenden Spannung zeigt, ohne weiteres ersichtlich. Im Betrieb fließt durch das Kathodophon ein Strom von etwa a_0 10^{-3} A, dem sich die vom Schall hervorgerufene sehr geringe Wechselstromkomponente von etwa 10^{-6} A überlagert.

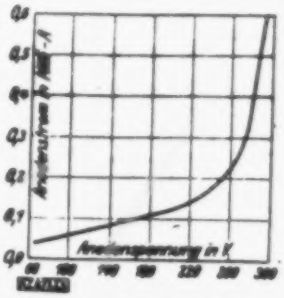

Abb. 3. Strom- und Spannungscharakteristik des Kathodophons.

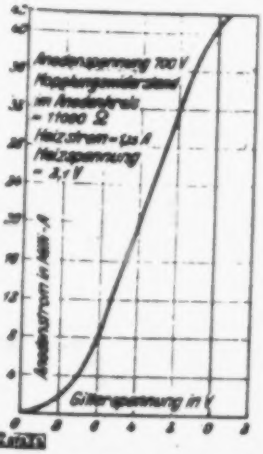

Abb. 5. Kennlinie einer Tri-Ergon-Röhre.

2. Verstärkung der durch Schall beeinflußten Ströme.

Da, wie ohne weiteres einzusehen ist, der vom Kathodophon schallgemäß modulierte Strom bei der Geringfügigkeit seiner Änderungen unmöglich zur Erzielung einer kräftigen Lichtwirkung ausreicht, um die rasch vorübergleitende Bromsilberschicht des Filmes genügend zu belichten, bedarf es einer Verstärkung. Ein bequemes Mittel, die Amplitude schwacher Ströme ohne Nachteile für ihre Charakteristik zu vergrößern, ist die inzwischen durch die Fortschritte der Radiotelephonie bekannt gewordene Verstärkerröhre[2]). Ihre Wirkung beruht darauf, daß der Strom einer elektrischen Entladung unter Luftleere durch ein elektrisches Feld, also ohne Arbeitsaufwand, beeinflußt werden kann. Im Rahmen dieser Arbeit kann auf diesen Vorgang nicht näher eingegangen werden. Es sei nur erwähnt, daß das Tri-Ergon eine eigene Röhrenart mit Raumladungselektrode und Anodenschutznetz in seinem Laboratorium entwickelt hat. Der Aufbau dieser Röhre, die nunmehr von Siemens & Halske hergestellt wird, geht aus Abb. 4 hervor; ihre elektrischen Kennwerte zeigt Abb. 5, wobei ein im Anodenkreis liegender Kopplungswiderstand von etwa 10 000 Ω in die Messung einbezogen ist.

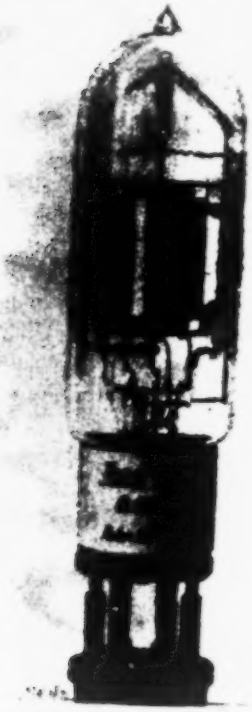

Abb. 4. Tri Ergon-Röhre

Infolge gleichzeitiger Anwendung eines Raumladungsgitters und einer Oxydkathode zeigt diese Verstärkerröhre eine beträchtliche Stromsteilheit; das Anodenschutznetz bedingt eine sehr geringe Einwirkung des Feldes der Anode auf das des Gitters, wodurch die Röhre besonders geeignet ist für ihre Verwendung in widerstandsgekoppelten Verstärkern.

Ursprünglich wurden die Röhren bei Niederfrequenzverstärkung nur induktiv, also über Transformatoren miteinander gekoppelt. Aus der Erkenntnis heraus, daß derartige Schaltungen sich im Gebiete der akustischen Frequenz stark selektiv verhalten, wodurch die verhältnisrichtige Übertragung gefährdet würde, entschied sich das Tri-Ergon für Verstärker mit Widerstandkopplung[3]), die den Bedingungen hinsichtlich Verzerrungsfreiheit am besten entsprechen. Die vom Tri-Ergon durchgebildete Einrichtung zur Aufnahmeverstärkung ist in der Lage, die Energie des Kathodophons frequenzunabhängig auf etwa 10 Watt schwingende Energie zu verstärken, eine Wechselstromleistung, die völlig ausreichend ist, um Einrichtungen zur Erzeugung des erforderlichen Lichtstromes zu betätigen.

3. Erzeugung von Lichteindrücken durch den verstärkten Strom.

Die Aufgabe besteht hier darin, durch den von der letzten Kaskade des Widerstandverstärkers geregelten Strom Lichteindrücke auf dem Negativfilm hervorzurufen. Mit Hilfe des Lichtes Schallwellen aufzuschreiben wurde verschiedentlich versucht. So war es vor allem Ruhmer, der 1898[4]) das Licht einer Bogenlampe, in deren Stromkreis Mikrophone lagen, auf einen vorübergleitenden Film einwirken ließ und so ein photographisches Phonogramm erhielt. Timm-Berglund[5]) und andere ließen die Schallwellen auf ein kippbares, einen Lichtstrahl zurückwerfendes Spiegelchen einwirken; Pleiß[6]) und Hülsmeyer[7]) betätigen elektromagnetisch ähnliche, einen unveränderlichen Lichtstrom regelnde Mechanismen.

Das Tri-Ergon benutzt zur Umsetzung der raschen elektrischen Impulse in Lichtänderungen eine elektrische Glimmlichtentladung[8]) in verdünnten, photochemisch stark wirksamen Gasen. Dieser Vorgang liegt allen Lichtquellen, deren Leuchten auf den Durchgang der Elektrizität durch Gase oder Dämpfe zurückzuführen ist, zugrunde (Quecksilberdampflampe, Moorelicht usw.). Die Versuche, die das Tri-Ergon anstellte, eine trägheitslose Lichtquelle zu erhalten, die bei den gegebenen Verhältnissen (Verstärkerleistung, Lichtstärke der optischen Einrichtung, Filmgeschwindigkeit, Filmempfindlichkeit und Schlitzbreite) das Negativ ausreichend belichtet, gipfeln in der Ultrafrequenzlampe, Abb. 6. In dieser Lampe erzeugt man, Schaulinie in Abb. 7, mit etwa 450 V und 0,015 A eine

[1]) DRP Nr. 348025.
[2]) Z. Bd. 69 (1925) S. 1233 u. f.
[3]) DRP 367058.
[4]) Annalen der Physik 1901 S. 933.
[5]) Schwedisches Patent Kl. 21 372 von 1909 und 37 085 von 1911.
[6]) Britisches Patent Nr. 15 302/13.
[7]) Britisches Patent Nr. 19 091/12.
[8]) DRP Nr. 368 367.

Abb. 2. Ultrafrequenzlampe.

Glimmlichtentladung, deren spezifische Helligkeit wesentlich höher ist als bei den bisher bekannten auf Glimmentladung beruhenden Lichtquellen. Das ausgestrahlte Licht einer derartigen mit Argon oder Stickstoff gefüllten und daher photographisch stark wirksamen Lumineszenzlampe ist dem durchgehenden Strom stets verhältnisgleich.

Diese Lampe löst also die Aufgabe, die den Schallwellen entsprechenden elektrischen Wechselströme (bis zu 20 000 Per./s) ohne Nachleuchten oder sonstige Trägheitserscheinungen in Lichtänderungen umzusetzen; sie dürfte auch für andere Zwecke, z. B. für rein wissenschaftliche und medizinische Zwecke, für Bildtelegraphie usw. Bedeutung erlangen.

4. Abbildung der Lichtänderungen auf dem Negativ.

Auf den mit der üblichen Geschwindigkeit von 0,36 m/s sich bewegenden Film muß das sich ändernde Licht der Ultrafrequenzlampe so einwirken, daß die zeitlichen Änderungen des Lichtes, selbst bei den kürzesten Intervallen, räumlich als Durchlässigkeitsänderungen der entwickelten Bromsilberschicht unterscheidbar sind.

Zur Erreichung dieses Zieles hätte man aus Gründen der Abbildung einer linear ausgedehnten Lichtquelle bedurft. Da aber die Herstellung derartiger Lichtquellen, die gleichzeitig den andern Bedingungen (spezifische Helligkeit, Trägheitslosigkeit) zu entsprechen hätten, sehr schwierig, wenn nicht unmöglich ist, benutzte das Tri-Ergon einen in den Strahlengang einer Projektionslichtquelle eingefügten Spalt und bildete dann die durch den Spalt erzeugte Lichtlinie in verkleinertem Maßstab auf dem Film ab. So ist es möglich, eine Lichtlinie von der erforderlichen geringen Breite (rd. 0,01 mm) auf dem Negativ zu erhalten. Die geringe Breite dieser Linie gewährleistet, daß bei der normalen Filmgeschwindigkeit hohe Frequenzen nicht „verwischt" werden, wodurch die Güte der Aufzeichnungen leiden würde.

Die genaue Führung des Filmes im Brennpunkt des Objektivs war nur dadurch möglich, daß man den Tonfilm während der Belichtung über eine gezahnte Rolle laufen ließ. Diese Rolle in Verbindung mit einem Schwungrad hatte eine weitere Aufgabe; ihr oblag es auch, den Film während des Belichtungsvorganges mit völlig gleichbleibender Geschwindigkeit fortzubewegen[1]). Abb. 8 zeigt eine derartige Vorrichtung zum Aufschreiben und zum Durchleuchten photographischer Phonogramme.

Abb. 8. Vorrichtung zum Aufschreiben bzw. Durchleuchten photographischer Phonogramme.

5. Entwickeln und Vervielfältigen der Filme.

Auch durch die Vorgänge beim Entwickeln, sowie durch das Kopieren darf die Proportionalität zwischen Lichteindruck auf dem Negativ und Durchlässigkeit des Positivs nicht leiden, soll der Schall bei der Wiedergabe keine Verzerrungen aufweisen. Verschiedene Gründe, vorwiegend durch die Praxis der Vorführung bestimmt, erforderten es, Tonpositiv und Bildpositiv auf einen gemeinsamen Träger aufzubringen, was die Aufgabe verwickelter machte.

Im Negativprozeß werden die Bild- und Tonvorgänge aus Gründen der Entwicklung auf getrennten Filmbändern von gewöhnlicher Breite aufgenommen. Führung mittels der Durchlochungen und Antrieb der Leitrollen mittels gelochter Bänder durch einen gemeinsamen Motor gewährleisten bei der Aufnahme die erforderliche genaue Synchronität. Durch Marken auf den beiden Negativen werden beim späteren Kopiervorgang die zusammengehörigen Stellen sicher ermittelt. Das „Bild"-Negativ wird in der üblichen, innerhalb der kinematographischen Industrie gebräuchlichen Weise entwickelt, wobei es der Erfahrung des betreffenden Arbeiters anheimgegeben ist, die unvermeidbaren Unterschiede in der Bildbelichtung durch geeignete Be-

[1]) DRP Nr. 399 315, 399 316.

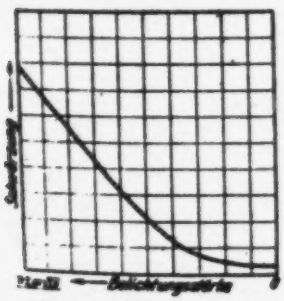

Abb. 9. Schwärzungslinie des Positivfilmes bei verschiedener Belichtungsstärke.

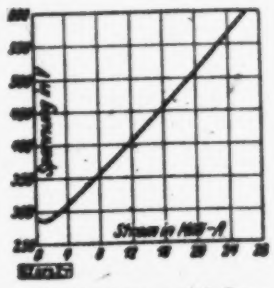

Abb. 7. Strom- und Spannungslinie einer Ultrafrequenzlampe.

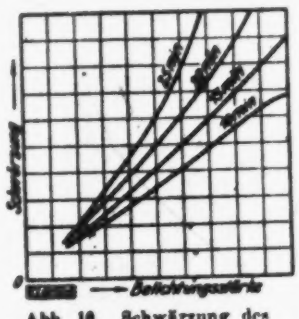

Abb. 10. Schwärzung des Negativfilmes bei verschiedener Entwicklungszeit.

Abb. 11. Positivfilm mit Tonstreifen.

handlung jedes einzelnen Bildnegativabschnittes auszugleichen. Das Tonnegativ wird völlig mechanisch entwickelt, wobei Stärke des Entwicklers, Temperatur und Entwicklungszeit ein für allemal bestimmt sind und genau eingehalten werden müssen. Infolge des gekrümmten Auslaufs der Schwärzungslinie des Positivfilmes am unteren Ende, Abb. 3, und der Notwendigkeit, aus Lichtdurchlässigkeitsgründen das Phonogramm in diesen Bereich zu verlegen, mußte Sorge getragen werden, die damit zusammenhängende Unproportionalität zu verkleinern. Dies gelang durch starke Krümmung der Entwicklungslinie des Negativfilms nach der entgegengesetzten Seite, was, wie Abb. 10 zeigt, praktisch durch beträchtliches Überentwickeln erreicht wird[1]). Beim Ton-Positivfilm, der von einem derartig behandelten Negativ gewonnen wird, verläuft sodann die Schwärzungslinie, wie erforderlich ist, gerade.

Für die Wiedergabe werden, wie schon erwähnt, Bild und Ton auf einen gemeinsamen Träger mittels einer vom Tri-Ergon eigens für diesen Zweck geschaffenen Durchlaufkopiermaschine kopiert. Abb. 11 zeigt das neue Positiv (eine Sprechfilmaufnahme des Ministers Stresemann, womit er die Kino- und Photomesse 1925 in Berlin eröffnete), das sich vom üblichen, 34 mm breiten, nur durch einen um 7 mm breiteren Rand unterscheidet. Die Abmessungen der Lochung sind dieselben geblieben. Da durch wird ermöglicht, daß auf den Projektoren, die für die Wiedergabe sprechender Filme geschaffen worden sind, auch die zur Zeit handelsüblichen „stummen" Filme vorgeführt werden können. Erwähnt sei noch, daß die zu einer bestimmten Stelle der Bildreihe gehörige Phonogrammstelle räumlich auf dem Positiv nicht unmittelbar daneben liegen kann. Bei den üblichen Bildprojektoren, die vom Tri-Ergon benutzt wurden, wird die kinematographische Wirkung durch ruckweise eintretenden Vorschub der Filmbilder erzeugt. Das Phonogramm dagegen beansprucht eine völlig gleichmäßige Bewegung. Diese Schwierigkeit wurde durch Gegeneinanderverschieben der zusammengehörigen Ton- und Bildstellen auf dem Positiv um etwa 50 cm überwunden; eine dazwischen liegende Schleife verhindert, daß sich die Ruckbewegungen des Filmbandes an der Projektionsstelle des Phonogrammes geltend machen.

[1]) DRP [illegible].

6. Erzeugung von Wechselstromvorgängen durch Lichtänderungen.

Bei der Reproduktion kommt es zunächst darauf an, durch das vorübereilende photographische Phonogramm Lichtänderungen herbeizuführen und mit deren Hilfe einen ihnen in seiner Charakteristik genau entsprechenden Wechselstrom zu erzielen.

Ein allgemein bekanntes Hilfsmittel bei der Übertragung von Lichtänderungen in elektrische Änderungen ist das Selen. Bei früheren Versuchen, akustische Vorgänge optisch aufzuzeichnen, bediente man sich seiner fast ausnahmslos. Die zu Beginn unserer Arbeiten erhältlichen Selenzellen zeigten aber eine vorwiegend zeitlich sich äußernde Unproportionalität zwischen einfallender Lichtmenge und Strom bzw. Widerstand.

Das Tri-Ergon umging die Schwierigkeiten, die mit der Verwendung derartiger, ihr Leitvermögen in Abhängigkeit vom Licht ändernden Verbindungen auftreten, grundsätzlich, indem es an ihrer Stelle die auf Elektronenabspaltung im Vakuum beruhende Alkalimetallzelle, von Elster und Geitel 1902 für astronomische Zwecke angegeben[2]), einführte[3]). Zwar ist der innere Widerstand der Photozelle, Abb. 12, bei den zur Verfügung stehenden Lichtmengen beträchtlich (rd. $10^8\,\Omega$), dementsprechend waren auch die zu überwindenden Kopplungsschwierigkeiten in Anbetracht der geforderten Frequenzunabhängigkeit nicht gering. Doch gelang es, durch Maßnahmen, auf die im Rahmen dieses allgemeinen Berichtes nicht eingegangen werden kann, auch diese Schwierigkeit zu beheben.

Der Film wird mit einer Lichtquelle von hoher spezifischer Helligkeit (z. B. Bogenlampenkrater) unter Verwendung von Einrichtungen durchleuchtet, die den zur Aufnahme und Belichtung des Negatives verwendeten ähn-

[2]) Physikalische Zeitschrift Bd. 11, S. 257, Bd. 12, S. 758.
[3]) DRP Nr. 417 987.

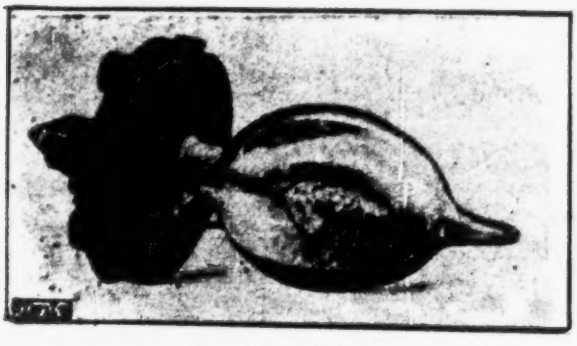

Abb. 12. Kaliumzelle von Elster und Geitel.

Abb. 13. Bildtonfilm-Projektor.

lich sind. Im Brennpunkt der Linsenanordnung, wo die erforderliche Lichtlinie entsteht, läuft der über den Rand der Leitrolle herausragende Filmteil, der das zu durchleuchtende Phonogramm trägt. Im Innern der freitragend laufenden Rolle ist die lichtempfindliche Zelle so angebracht, daß ihre Kaliumhydrürschicht dem einfallenden und durch den Film gesteuerten Lichtstrom ausgesetzt ist, s. Abb. 8. Bei einer Zellenspannung von 120 bis 150 V schwankt der gesteuerte Strom um einige Mikroampere.

7. Verstärkung des Photozellenstromes.

Diese Aufgabe ist der bereits bei der Aufnahme gegebenen und bereits besprochenen ähnlich, nur sind die zu überwindenden Schwierigkeiten wegen des erforderlichen höheren Verstärkungsgrades und der Fernhaltung von Störungen wesentlich größer.

Die Stromänderungen der lichtempfindlichen Zelle werden über einen Kondensator der Widerstandsverstärkeranordnung, die der bei der Aufnahme verwendeten ähnlich ist, zugeführt. Diese Anordnung verstärkt die Änderung des Bildstromes auf im Mittel $40 \cdot 10^{-6}$ A. Ein derartiger Strom ist erforderlich, um die Schallwiedergabegeräte so zu betätigen, daß sie für die größten Vorführungsräume ausreichen. Die Verstärkungsanordnung, die ihren Strom von einer kleinen Hochspannungs-Akkumulatorenbatterie von 700 V erhält, ist zusammen mit dieser und den Einrichtungen für die Projektion des Bildes und des Tones zu einem Gerät, dem „Bildtonfilm-Projektor", zusammengebaut. Abb 13, zeigt diesen Apparat einschließlich der vier Lautsprecher und der Lautstärkenregelung.

8. Wiedergabe des Schalles.

Für die Rückbildung der verstärkten Wechselströme in Schallfrequenzen wurden Einrichtungen geschaffen, bei denen die Nachteile, die den üblichen Lautsprecheinrichtungen eigen sind (Trichterton, Selektivität in bezug auf bestimmte Frequenzgebiete, Trägheit der schwingenden Massen), möglichst vermieden wurden.

Fast allbekannt gewordenen Telephone oder Lautsprecher beruhen auf elektromagnetischer Wirkung. Das Tri-Ergon hielt diese schon 1919 für ungeeignet zur Schaffung schallabgebender Flächen für große Schallstärken. Es hielt die elektrostatische Anziehung trotz der Vernachlässigung, die sie bisher in der Telephontechnik gefunden hat, für viel geeigneter zur Erreichung des obigen Zweckes. Das Ergebnis dieser erfolgreichen Arbeiten ist das Statophon, ein kapazitiver Lautsprecher, dessen beträchtlich große Membran durch veränderliche statische Felder erregt wird und das imstande ist, ohne Zuhilfenahme nachteiliger Trichterwirkungen beträchtliche Schallmengen abzugeben[1]). Dieses Statophon besteht aus einer gespannten mit Metall belegten Glimmermembran

[1]) DRP Nr. 368 99, 368 98, 367 82.

Abb. 14 und 15. Schema des Statophons.

von 20 bis 40 cm Dmr. und 0,08 mm Dicke und aus einem durchbrochenen feststehenden Belag. Zwischen beiden sind die elektrostatischen Kräfte wirksam. Um Frequenzunabhängigkeit zu erzielen, hat man die Membranen in exzentrische Ringmembranen unterschiedlicher Breite zerlegt, ein Verfahren, das bei verschiedenen Statophonen in allmählicher Abstufung durchgeführt worden ist, damit auch hier das gesamte Gebiet der von diesen Lautsprechern bevorzugten Frequenzen verbreitert wird. Abb. 14 und 15 zeigen schematisch die Anordnung des Statophons in Aufsicht und Querschnitt. Abb. 16 zeigt einen Statophonsatz, bestehend aus drei einzelnen Statophonen für hohe, tiefe und mittlere Frequenzen, der genügt, einen großen Kinoraum mit Schall zu füllen.

Zusammenfassung.

Die Aufnahme von Bildtonfilm vollzieht sich in Werkstätten, die nicht nur lichttechnisch, sondern auch schalltechnisch nach besonderen Gesichtspunkten gebaut sind; jedes Nebengeräusch, jede Schallreflexion muß vermieden werden. Das kinematographische Aufnahmegerät ist mit der Tonaufzeichnungseinrichtung zu einer gemeinsamen Einrichtung, der Bildtonfilm-Aufnahmekamera, die elektrisch angetrieben wird, vereinigt. Kathodophon und Verstärker wiederum bilden ebenfalls ein einziges Gerät, das nur durch ein Kabel mit der Aufnahmekamera zusammenhängt, so daß es unabhängig vom Stande der Kamera an die akustisch günstigste Stelle im Aufnahmeraum gestellt

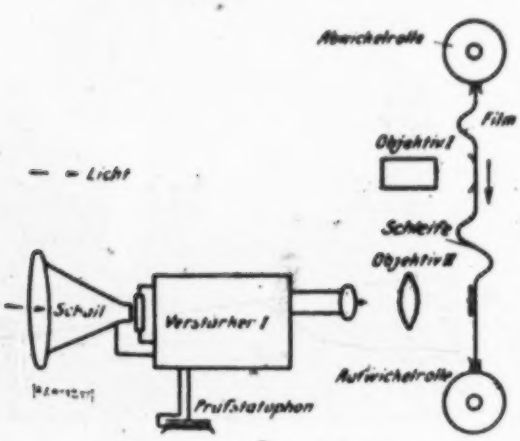

Abb. 17. Bildtonfilm-Aufnahme.

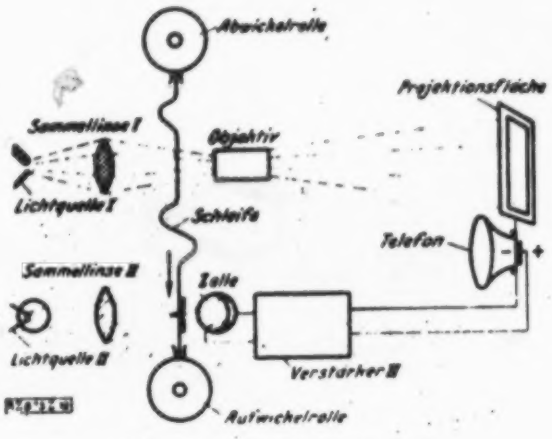

Abb. 18. Bildtonfilm-Wiedergabe.

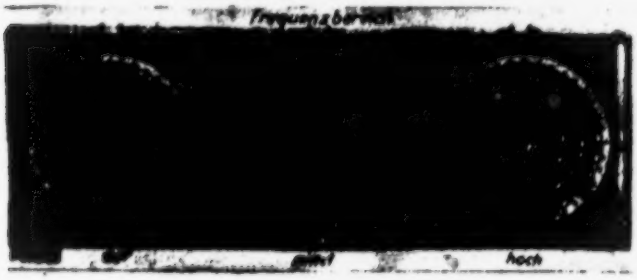

Abb. 16. Statophonsatz.

werden kann. Während der Aufnahme ist ein in einem Nebenraum angebrachtes Prüfstatophon mit eingeschaltet. Das Aufnahmegerät muß völlig geräuschlos arbeiten, da die Schallaufnahme genau wie das Ohr alle Schallvorgänge verzeichnet, auch jene, die ihre Ursache außerhalb der Handhabung haben. Abb. 17 zeigt schematisch das Zusammenwirken der Einrichtungen bei der Aufnahme.

Zum Zwecke der Wiedergabe wird der in Abb. 13 abgebildete Bildtonfilm-Projektor im Vorführungsraum eines Lichtbildtheaters aufgestellt, die Statophone, Abb. 15, werden neben der Projektionsfläche angebracht und durch ein Kabel mit dem Wiedergabeverstärker verbunden. Eine den Verstärkungsgrad beeinflussende Regelvorrichtung gestattet es, auf die erforderliche Lautstärke einzustellen. Da das Phonogramm völlig synchron mit dem kinematographischen Bild abläuft, so ist beim Theaterbesucher der Eindruck, daß das bewegte Bild auch die Quelle des Schalles sei, vollkommen. Eine durch etwaiges Reißen des Filmbandes bedingte Verkürzung von mehreren Dezimetern macht sich selbst bei Filmstellen mit lebhaften Vorgängen gehörmäßig weniger bemerkbar als im Bild. In Abb. 18 ist die Wiedergabeeinrichtung für sprechende Filme nach dem Tri-Ergon-Verfahren schematisch dargestellt.

In Deutschland hat die Universum Film-Aktiengesellschaft eine Lizenz auf das Tri-Ergon-Verfahren erworben. Sie ist gegenwärtig damit beschäftigt, die ersten Filme nach dem neuen Verfahren herzustellen. [B 873]

Leuchtende piezoelektrische Resonatoren.

Einem Vortrag von Prof. Dr. Giebe in einer Sitzung des Elektrotechnischen Vereins, Berlin, am 10. December, sind folgende bemerkenswerte Mitteilungen zu entnehmen.

Die von J. und P. Curie im Jahre 1900 entdeckte Erscheinung der Piezoelektrizität gewisser Kristalle äußert sich in zwei Wirkungen: erstens unmittelbar, d. i. in einer dielektrischen Polarisation des Kristalls infolge elastischer Verformung, zweitens in der umgekehrten Wirkung, d. i. in einer elastischen Verformung des Kristalls infolge dielektrischer Polarisation. Wie der Amerikaner Cady neuerdings gezeigt hat, kann man einen piezoelektrischen Kristall, etwa in Stabform, durch ein elektrisches Wechselfeld vermöge des umgekehrten Piezoeffekts zu stehenden, elastischen Längsschwingungen sehr hoher Frequenz anregen, wenn die Frequenz des erregenden Feldes übereinstimmt mit einer elastischen Eigenfrequenz des Kristallstabes. Das Eintreten der Resonanz zwischen elektrischen und elastischen Schwingungen beobachtet man nach Cady an der Rückwirkung des „piezoelektrischen Mitschwingers" (Resonators) auf den ihn erregenden elektrischen Schwingungskreis mit Hilfe eines Stromzeigers, der in den Schwingungskreis eingeschaltet ist, oder auch akustisch mit einem Telephon in geeigneter Empfängerschaltung.

Die neuen leuchtenden piezoelektrischen Resonatoren, die von E. Giebe und A. Scheibe in der Physikalisch-Technischen Reichsanstalt erfunden sind, beruhen darauf, daß durch die Verformungen eines piezoelektrisch zu Längsschwingungen angeregten Quarzstabes sekundär piezoelektrische Spannungen entstehen. Diese Spannungen, die bei Resonanz recht hoch sind, erzeugen nun unter gewissen Versuchsbedingungen, zu denen insbesondere Einschluß der Mitschwinger in einen luftverdünnten Raum gehört, eine leuchtende elektrische Entladung. Das Leuchten tritt nur ein, wenn Resonanz besteht zwischen den erregenden elektrischen Schwingungen und den erregten elastischen Schwingungen und kann daher zur Resonanzanzeige benutzt werden.

Die Empfindlichkeit derartiger leuchtender Mitschwinger ist außerordentlich groß. Man kann es so einrichten, daß der Quarzstab nur dann aufleuchtet, wenn die Frequenz der erregenden elektrischen Schwingungen nicht mehr als $^{1}/_{100}$ vH von einer der Längsschwingungs-Eigenfrequenzen des Stabes abweicht. Welche der Eigenfrequenzen jeweils zur Anregung kommt, ist ohne Schwierigkeit aus der Form der Leuchterscheinung zu ersehen. Ein Quarzstab von 80 mm Länge, dessen elastische Grundfrequenz 34 100 Hertz (8800 m elektrische Wellenlänge) beträgt, konnte außer in seiner Grundschwingung in Oberschwingungen bis zur 21ten (720 630 Hertz) leuchtend angezeigt werden.

Die leuchtenden Resonatoren sind ein sehr einfaches Hilfsmittel, um einen Sender, z. B. einen Rundfunksender, ohne Benutzung irgendwelcher Meßgeräte mit großer Genauigkeit stets wieder auf die gleiche Wellenlänge einzustellen. Bei dem Berliner Sender in Witzleben ist bereits seit einigen Monaten ein auf Welle 505 m abgestimmter Mitschwinger im Dauerbetrieb. [N 1202]

Rückschluß auf die Wahrscheinlichkeit seltener Ereignisse.

Mit der wissenschaftlichen Durchdringung der Betriebsorganisation und zumal der Menschenwirtschaft dürfte für den Ingenieur die Wahrscheinlichkeitsrechnung mehr und mehr an Bedeutung gewinnen, weil Vorhersagen auf Grund von Eignungsuntersuchungen, Zeitstudien und dergleichen niemals „bestimmt", sondern stets nur „wahrscheinlich" sein können. So hat auch für Versicherung, Lotterie usw. die Wahrscheinlichkeitsrechnung immer schon als Grundlage gedient. In exakter, mathematischer Form beschäftigt sich neuerdings Pollaczek-Geiringer mit den Fragen der Wahrscheinlichkeitsrechnung (ZAMM Bd. 5 (1925) S. 493 bis 501).

Zunächst werden die beiden grundsätzlichen theoretischen Fragestellungen, bekannt als die Bernoullische und Bayessche, und die dafür von Bernoulli, Poisson und Bayes entwickelten Formeln dargelegt. Bernoulli fragt nach der Wahrscheinlichkeit dafür, daß man aus einer Urne, die schwarze und weiße Kugeln in irgendeinem Mischungsverhältnis enthält, in n Zügen gerade x weiße und $(n-x)$ schwarze Kugeln erhält, wobei jedesmal die herausgenommene Kugel wieder in die Urne zurückgelegt wird. Die Problemgruppe von Bayes setzt eine Reihe von Urnen mit schwarzen und weißen Kugeln in verschiedenen Mischungsverhältnissen voraus. In n Zügen aus einer Urne sei n_1-mal „weiß" gezogen worden, wobei auch jedesmal die gezogene Kugel wieder zurückgelegt wird.

Gefragt wird nun nach der Wahrscheinlichkeit dafür, daß in der Urne, aus der die n Ziehungen erfolgt sind, die Wahrscheinlichkeit eines weißen Zuges gerade x ist, oder, wie auch gesagt werden kann, das Mischungsverhältnis x herrscht. Man spricht hier von einer Wahrscheinlichkeit des Rückschlusses auf das Mischungsverhältnis x und nennt sie auch Wahrscheinlichkeit „a posteriori", während man mit „a priori" die Wahrscheinlichkeit dafür bezeichnet, daß man beim Ziehen unter allen möglichen Urnen gerade eine trifft, in der das Mischungsverhältnis x herrscht. Pollaczek-Geiringer setzt nun ein großes n und ein im Verhältnis dazu kleines n_1 voraus und leitet dann eine einfache Näherungsformel zur Berechnung der Wahrscheinlichkeit dafür ab, daß der Erwartungswert $n\,x$ in der Nähe einer bestimmten Größe liegt.

Bei Anwendung auf eine Statistik über Kindermorde in Preußen aus den Jahren 1869 bis 1893 wird z. B. nach der Wahrscheinlichkeit dafür gefragt, daß der Erwartungswert der in 25 Jahren verübten Knabenselbstmorde zwischen 48 und 50 liegt. Es handelt sich hier zugleich um das Problem der „wahrscheinlichen Grenzen", bei deren genauerer Berechnung sich zeigt, daß sie nicht symmetrisch zum wahrscheinlichsten Wert liegen.

Die Untersuchung wird schließlich noch auf das mehrdimensionale Bayessche Problem ausgedehnt, wobei die Urne, aus der n-mal gezogen wird, nicht nur schwarze und weiße Kugeln, sondern auch solche mit noch andern Kennzeichen enthält. [N 1304] Hanke

Translation by George C. O. Haas, Ph.D., of New York.

[Zeitschrift des Vereines Deutscher Ingenieure, vol. 70, no. 6, Berlin, February 6, 1926, pages 199-204]

THE TALKING FILM ACCORDING TO THE TRI-ERGON PROCESS.

By Hans Vogt, of Berlin-Wilmersdorf.

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A report is given about a process for the production of "talking films", in which a novel inertialess microphone, amplifiers operating independently of the frequency, and an inertialess source of light are employed for the recording, and an alkali-metal cell and novel electrostatic loud-speakers for simultaneous reproduction of the tone with the cinematographic picture.

The desirable goal of creating a contrivance which renders it possible to seize the visible and the audible aspect of the occurrences of life simultaneously and to reproduce them simultaneously could not, as the development of the last few decades showed, be attained by simple combination of the film with the gramophone. None of the ingenious mechanical synchronization contrivances could permanently assure that completely uniform run-off of the correlative film and phonogram places which is a prerequisite for the impression of correlativity; since in the temporal sequence even a difference of 1/20 of a second is sufficient to destroy for the observer the impression of talking photography.

Only as a result of the resumption of the process, known since the beginning of this century, of recording the sound-waves photographically, in consequence of which it became possible to put the phonogram and the serial picture upon a common carrier, the celluloid film, and to get around the problem of synchronism, and furthermore as a result of the creation of new technical

means for the recording and reproduction of sound-waves, did that solution become possible about which I intend to report in what follows and which has already demonstrated its practical usefulness in prolonged series of presentations.

The necessary labors were carried out by Joseph Massolle, Dr. Jo Engl, and the author in Berlin during the period from 1918 to 1924 in equal participation. This inventor group, which was formed at the suggestion of the author for joint work on this problem, applied to itself the distinctive word "Tri-Ergon". This word was also used to designate the results of the joint activity, as well as the enterprise [1] conducting the economic exploitation of these inventions.

The problem as a whole.

On the assumption that only that photographic recording which makes it possible to secure phonograms next to the serial pictures of the usual film with the well-known photographic means has any prospect of fully meeting the requirements of actual practice, we would get somewhat the following technical problem as a whole.

The sound-waves issuing from the action that is to be recorded would, for reasons of the necessary amplification, first have to be used for variation of an electric current. The latter would have to produce variations of light, which would have to be photographically recorded, multiplied, and reproduced together with the picture occurrence. In the reproduction, by means of the transilluminated photographic sound-wave picture, a variable electric current would have to be produced, which would have to be used for actuation of the actual means for sound-reproduction. In all of these conversions it would have to be a require-

[1] Tri-Ergon A.-G., of Zurich.

ment that the characteristic curve of the sound-vibrations should suffer no distortion in the various conversions. Finally, the volume of sound to be reproduced would have to correspond approximately with that present at the recording.

The problem as a whole would have to be divided into a series of separate problems, which, together with the solutions which were discovered, are now to be described.

The partial problems and their solution.

1. Conversion of fluctuations of sound-pressure into electric fluctuations.

All sound-vibrations occurring in practice from about 50 to about 15,000 cycles per second must be recorded, within the distances determined by the action, during the cinematographic recording, i. e. must be "converted" into variations of an electric current.

The contrivances which were employed at the beginning of the labors of the Tri-Ergon were the well-known carbon-grain microphones. Their drawbacks, namely the prominence of resonance positions of their oscillating parts and noises caused by shifting of their filling-material, rendered them unserviceable for the purpose intended. There appeared to be no prospect of securing the requisite purity with them. The problem of creating a qualitatively valuable microphone which was devoid of oscillating material parts and which converted the fluctuations of sound-pressure with perfect proportionality into fluctuations of an electric current, was solved by the invention of the cathodophone, a glowlight discharge sensitive to sound, Fig. 1. This new apparatus announced by the Tri-Ergon [2] depends upon the observation that a tiny glow discharge,

[2] German Patents Nos. 350500, 351955, 351956.

advantageously produced in the open air, with the use of ionizing means (oxides of the alkaline-earth group), at an incandescent cathode which behaves neutrally toward the oxygen of the air, varies its resistance under certain conditions under the influence of the sound-waves.

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Fig. 2 shows in diagram form the circuit of such a discharge gap that is sensitive to sound. In it *a* is a refractory cathode which is electrically heated by means of the battery *e* and is provided with calcium oxide. The anode *b* is constructed, for the purpose of collection of the sound, as a funnel whose capped open point is situated opposite the cathode with an interval of about 1/10 millimeter. Under the influence of the electric field of about 300 volts which is produced between *a* and *b* by the anode battery *c*, negatively charged particles leave the cathode and, in consequence of the high pressure occasioned by the open air, travel at a relatively low velocity to the anode. The sound, introduced into the path of the discharge through the anode constructed in funnel shape, now influences the emission process in a manner which is theoretically not yet entirely cleared up, so that the resistance of the discharge gap or the current in the anode circuit under particular technical prerequisites varies proportionately to the intensity, the frequency, and the characteristic curve of the sound that is introduced, and produces an electric alternating current which correctly represents the sound and which can be tested as sound again by means of the listening-instrument *d* connected into the anode circuit. The sensitiveness of this contrivance is considerably increased if the anode potential is chosen so high that impact ionization occurs in the discharge gap.[1] This effect is directly apparent from Fig. 3, which shows

[1] German Patent No. 368025.

the dependence of the anode current upon the potential connected to the cathodophone. In operation there flows through the cathodophone a current of about $0.5 \cdot 10^{-3}$ ampere, upon which the very slight alternating-current component of about 10^{-6} ampere, produced by the sound, is superimposed.

2. Amplification of the currents which have been influenced by sound.

Since, as can be readily understood, the current which has been modulated in accordance with the sound by the cathodophone, in view of the insignificance of its variations, cannot possibly suffice for the attainment of a powerful light-effect, so as adequately to expose the rapidly passing silver-bromide layer of the film, an amplification is required. A convenient means of increasing the amplitude of weak currents without disadvantages for their characteristic curve, is the amplifier tube [2] which has in the meantime come to be well-known as a result of the progress of radiotelephony. Its action depends upon the fact that the current of an electric discharge in a vacuum can be influenced by an electric field, i. e. without the expenditure of work. Within the scope of this article this process cannot be discussed in greater detail. We may merely mention that the Tri-Ergon developed in its laboratory a type of tube of its own, having a space-charge electrode and an anode protection-net. The construction of this tube, which is now being manufactured by Siemens & Halske, is evident from Fig. 4; its electric characteristic values are shown in Fig. 5, in which connection a coupling resistance of about 10,000 ohms, situated in the anode circuit, is included in the measurement.

[2] Zeitschrift, vol. 69 (1925), page 1243 and the following.

In consequence of simultaneous employment of a space-charge grid and an oxide cathode, this amplifier tube manifests a considerable current-steepness; the anode protection-net brings about a very slight action of the field of the anode upon that of the grid, in consequence whereof the tube is particularly suitable for its use in resistance-coupled amplifiers.

Originally, in low-frequency amplification, the tubes were coupled with one another only inductively, i. e. by way of transformers. As a result of the discovery that such circuits have a decidedly selective action within the range of acoustic frequency, in consequence whereof the proportionally correct transfer would be jeopardized, the Tri-Ergon decided in favor of amplifiers with resistance coupling,[3] which best meet the requirements with regard to freedom from distortion. The contrivance developed by the Tri-Ergon for amplification of the recording is capable of amplifying the energy of the cathodophone, independently of the frequency, to about 10 watts of oscillating energy, an alternating-current power which is entirely sufficient to actuate contrivances for the production of the requisite stream of light.

3. Production of light-impressions by means of the amplified current.

Here the problem consists in producing light-impressions on the negative film by means of the current which is regulated by the last cascade of the resistance amplifier. Various attempts were made to record sound-waves with the aid of light. Thus it was primarily Ruhmer who in 1898[4] caused the light of an arc lamp, in whose circuit microphones were situated, to act upon a passing film and thus obtained a

[3] German Patent No. 387059.
[4] Annalen der Physik, 1901, page 803.

photographic phonogram. Timm-Berglund [5] and others caused the sound-waves to act upon a small mirror capable of being tipped and reflecting a ray of light; Pleits [6] and Hülsmeyer [7] actuated mechanisms which were electromagnetically similar and which regulated an invariable stream of light.

The Tri-Ergon uses, for the conversion of the rapid electric impulses into variations of light, an electric glow-light discharge [8] in dilute gases which are photochemically highly active. This process constitutes the basis of all sources of light whose luminosity is to be attributed to the passage of electricity through gases or vapors (mercury-vapor lamp, Moore light, etc.). The experiments which the Tri-Ergon made for the purpose of obtaining an inertialess source of light which under the given circumstances (power of the amplifier, intensity of light of the optical contrivance, film speed, film sensitiveness, and width of the slit) sufficiently illuminates the negative, culminate in the ultrafrequency lamp, Fig. 6. In this lamp one produces—characteristic curve in Fig. 7—
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with about 450 volts and 0.015 ampere a glow-light discharge whose specific luminosity is substantially higher than in the hitherto known sources of light depending upon glow-light discharge. The radiated light of such a luminescence lamp, filled with argon or nitrogen and therefore photographically highly active, is constantly proportional to the current passing through it.

This lamp accordingly solves the problem of converting the electric alternating currents corresponding to the sound-waves (up to 20,000 cycles per second) into variations of light without afterglow or

[5] Swedish Patent No. 31472 of 1909 and 37065 of 1911.
[6] British Patent No. 15302/03.
[7] British Patent No. 19991/02.
[8] German Patent No. 368367.

other inertia phenomena; it may very well acquire importance also for other purposes, for instance for purely scientific and medical purposes, for picture-telegraphy, etc.

4. Picturing of the variations of light on the negative.

Upon the film, which moves at the usual speed of 0.38 meter per second, the varying light of the ultra-frequency lamp must act in such a way that the temporal variations of the light, even in the case of the shortest intervals, shall be spatially distinguishable as variations of translucency of the developed silver bromide layer.

For the attainment of this goal a linearly extended source of light would have been required for reasons of picturing. But inasmuch as the manufacture of such sources of light, which would at the same time have to meet the other requirements (specific luminosity, freedom from inertia), is very difficult, if not impossible, the Tri-Ergon used a slit introduced into the path of the rays of a projection source of light and then pictured the line of light produced by means of the slit upon the film on a reduced scale. Thus it is possible to get on the negative a line of light of the requisite small width (approximately 0.01 millimeter). The small width of this line makes it certain that at the standard film speed high frequencies will not be "blurred", as a result of which the quality of the records would be impaired.

The exact guidance of the film at the focus of the objective was possible only by causing the tonefilm to run over a toothed roller during the exposure. This roller in conjunction with a flywheel had an additional function; it was also incumbent upon it to move the film ahead at an entirely uniform speed during the process of exposure.[1] Fig. 8 shows such a contri-

[1] German Patents Nos. 389318, 389319.

vance for the recording and for the transilluminating of photographic phonograms.

5. The developing and multiplying of the film.

Then, too, the proportionality between the light-impression on the negative and the translucency of the positive must not be impaired as a result of the processes in the developing, nor as a result of the copying, if the sound is not to manifest any distortions in the reproduction. Various reasons, preponderantly determined by the practical operation of the presentation, rendered it necessary to put the tone positive and the picture positive upon a joint carrier, a circumstance which made the problem still more complicated.

In the negative process the picture occurrences and the tone occurrences are, for reasons of development, recorded on separate film strips of the ordinary width. Guidance by means of the perforations and drive of the feed rollers by means of perforated bands by a joint motor assure the requisite exact synchronism in the recording. By means of marks on the two negatives the correlative places are ascertained with certainty in the subsequent copying-process. The "picture" negative is developed in the usual manner that is customary in the motion-picture industry, in which connection it is left to the experience of the particular worker to equalize the unavoidable differ-

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ences in the picture exposure by suitable treatment of each individual section of the picture negative. The tone negative is developed entirely mechanically, in which connection the strength of the developer, the temperature, and the time of development are determined once for all and must be adhered to exactly. In consequence of the curved termination of the blackening-line of the positive film at the lower end, Fig. 9,

and the necessity of shifting the phonogram into this range for reasons of translucency, care had to be taken to diminish the disproportionality involved therein. This proved to be possible by means of decided curvature of the development line of the negative film toward the opposite side, a result which is attained in practice, as Fig. 10 shows, by considerable overdevelopment.[1] In the case of the tone positive film which is obtained from a negative which has been treated in this way, the blackening-line then extends straight, as is required.

For the reproduction, as has already been mentioned, the picture and the tone are copied upon a joint carrier by means of a passage copying-machine created by the Tri-Ergon particularly for this purpose. Fig. 11 shows the new positive (a talking film record of Minister Stresemann with which he opened the 1925 motion-picture and photographic fair in Berlin), which differs from the usual film, 34 millimeters in width, only by an edge which is 7 millimeters wider. The dimensions of the perforation have remained the same. By this means it is rendered possible that on the projectors which are created for reproduction of talking films the "silent" films which are at present commercially customary can also be presented. It may be mentioned, in addition, that the phonogram place which belongs to a particular place of the picture series cannot be spatially situated directly next to it on the positive. In the usual picture projectors, which are used by the Tri-Ergon, the cinematographic effect is produced by a feed of the film pictures which takes place intermittently. The phonogram, on the other hand, requires an entirely uniform movement. This difficulty was overcome by mutual displacement of the correlative tone places and picture places on

[1] German Patent 389598.

the positive to the extent of about 30 centimeters; an intervening loop prevents the jerky movements of the film strip from asserting themselves at the point of projection of the phonogram.

6. The production of alternating-current processes by means of variations of light.

In the reproduction it is essential, in the first place, to produce variations in light by means of the photographic phonogram which travels past, and with their aid to secure an alternating current which corresponds with them exactly in its characteristic curve.

A generally known expedient in the conversion of variations of light into electric variations is selenium. In earlier attempts to record acoustic occurrences optically it was used almost exclusively. The selenium cells which were obtainable at the commencement of our labors, however, manifested a disproportionality, preponderantly expressing itself temporally, between the incident quantity of light and the current or resistance.

The Tri-Ergon fundamentally got around the difficulties which occur with the use of such compounds, which vary their conductivity in dependence on the light, by introducing,[3] in place of them, the alkali-metal cell which was announced [2] by Elster and Geitel in 1902 for astronomical purposes and which depends upon the splitting-off of electrons in a vacuum. To be sure, the internal resistance of the photoelectric cell, Fig. 12, is considerable (about 10^6 ohms) with the quantities of light that are available; accordingly the difficulties of coupling which had to be overcome were not trifling, in view of the required independence of the frequency. But it proved possible, by expedients

[2] German Patent No. 417967.
[3] Physikalische Zeitschrift, vol. 11, p. 257; vol. 12, p. 758.

which cannot be discussed within the scope of this general report, to do away with this difficulty also.

The film is transilluminated by means of a source of light of high specific luminosity (for instance, an arc-lamp crater) with the employment of contrivances which are similar to those employed for the recording

[Page 203]

and the exposure of the negative. In the focus of the lens arrangement, where the required line of light is produced, there runs the portion of the film which projects beyond the edge of the feed roller and which carries the phonogram which is to be transilluminated. In the interior of the roller, which runs in a freely carrying manner, the optically sensitive cell is affixed in such a way that its layer of potassium subhydride is exposed to the incident stream of light, which is controlled by the film, cf. Fig. 8. At a cell potential of 120 to 150 volts, the controlled current fluctuates to the extent of several microamperes.

7. Amplification of the photoelectric-cell current.

This problem is similar to that which has already been indicated in connection with the recording and which has already been discussed, only the difficulties to be overcome are substantially greater because of the required greater degree of amplification and the keeping away of disturbances.

The variations of current of the optically sensitive cell are conducted by way of a condenser to the resistance amplifier contrivance, which is similar to that employed in the recording. This contrivance amplifies the variation of the picture current to, on an average, $40 \cdot 10^{-3}$ ampere. Such a current is required in order to actuate the sound-reproducing instruments in such a way that they suffice for the largest presentation halls. The amplifier contrivance, which receives its current from a small high-tension storage battery

of 700 volts, is built together with the latter and with the contrivances for the projection of the picture and of the tone to form one piece of apparatus, the "picture-tonefilm projector". Fig. 13 shows this apparatus inclusive of the four loud speakers and the regulation of the intensity of sound.

8. Reproduction of the sound.

For the reconversion of the amplified alternating currents into sound-frequencies, contrivances were created in which the drawbacks that are inherent in the usual loud-speaker contrivances (horn tone, selectivity with respect to particular frequency ranges, inertia of the vibrating masses) were obviated as far as possible.

Almost all telephones or loud speakers that have become known depend upon electromagnetic action. The Tri-Ergon as early as 1919 regarded this action as unsuitable for the creation of sound-delivering surfaces for high intensities of sound. It regarded electrostatic attraction, in spite of the neglect which it has hitherto experienced in telephone engineering, as far more suitable for the attainment of the above purpose. The result of these successful labors is the statophone, a capacitative loud speaker, whose membrane, of considerable size, is excited by means of variable static fields and which is capable, without the aid of detrimental horn effects, of delivering considerable quantities of sound.[1] This statophone consists of a tensed mica membrane, coated with metal, of a diameter of 20 to 40 centimeters and a thickness of 0.03 millimeter, and of a perforated stationary layer. Between the two, the electrostatic forces are active. In order to attain independence of the frequency, the membranes have been divided into eccentric annular

[1] German Patents Nos. 368899, 368900, 377921.

membranes of differing width, a procedure which has been carried out in different statophones in gradual gradation, in order that here also the total range of frequencies favored by these loud speakers may be extended. Figs. 14 and 15 show in diagram form the arrangement of the statophone in view from above and in cross-section. Fig. 16 shows a statophone set, consisting of three individual statophones for high, low, and intermediate frequencies, which is sufficient to fill a large motion-picture hall with sound.

Summary.

The recording of the picture-tonefilm is effected in studios which not only phototechnically, but also acoustotechnically, are built in accordance with special considerations; every subsidiary noise, every reflection of sound must be avoided. The cinematographic recording apparatus is combined with the tone-recording contrivance to form a joint contrivance, the picture-tonefilm recording camera, which is electrically driven. The cathodophone and the amplifier, in turn, likewise form a single piece of apparatus, which is connected with the recording camera only by a cable, so that, independently of the position of the camera, it may be placed at the acoustically most favorable

[Page 204]

place in the recording-room. During the recording a testing statophone placed in an adjoining room is also connected in. The recording apparatus must operate entirely noiselessly, since the sound-recording, precisely like the ear, registers all sound-occurrences, and also those which have their cause outside of the manipulation. Fig. 17 shows in diagram form the cooperation of the contrivances in the recording.

For the purpose of reproduction the picture-tonefilm projector illustrated in Fig. 13 is set up in the exhibition room of a motion-picture theater; the stato-

phones, Fig. 15, are placed next to the projection surface and connected with the reproducing amplifier by a cable. A regulating contrivance which influences the degree of amplification renders it possible to adjust to the requisite intensity of sound. Since the phonogram runs off in complete synchronism with the cinematographic picture, the theatre patron's impression that the animated picture is also the source of the sound is perfect. A shortening of several decimeters caused by possible tearing of the film strip is less noticeable auditorily, even at places of the film with lively occurrences, than in the picture. In Fig. 18 the reproducing contrivance for talking films according to the Tri-Ergon process is illustrated in diagram form.

In Germany the Universum Film-Aktiengesellschaft has acquired a license for the Tri-Ergon process. It is at present engaged in producing the first films by the new process.

[B 873]

[Wording of the illustrations.]

Fig. 1. Cathodophone.
[above] Cathode.
[below] Anode.

Fig. 2. Circuit of the cathodophone.
a cathode
b anode
c anode battery
d listening instrument
e heating battery

Fig. 3. Characteristic curve of the amperage and voltage of the cathodophone.
[ordinates] Anode current in milliamperes.
[abscissas] Anode potential in volts.

Fig. 4. Tri-Ergon tube.

Fig. 5. Characteristic curve of a Tri-Ergon tube.
Anode potential, 700 volts.
Coupling resistance in the anode circuit = 11,000 ohms.
Heating current = 1.25 amperes.
Heating potential = 2.1 volts.
[ordinates] Anode current in milliamperes.
[abscissas] Grid potential in volts.

Fig. 6. Ultrafrequency lamp.

Fig. 7. Current-curve and potential-curve of an ultrafrequency lamp.
[ordinates] Potential in volts.
[abscissas] Current in milliamperes.

Fig. 8. Device for the recording or transillumination of photographic phonograms.

Fig. 9. Blackening-line of the positive film in case of different intensity of illumination.
[ordinates] Blackening.
[abscissas] Intensity of illumination.

Fig. 10. Blackening of the negative film in case of different time of development.
[ordinates] Blackening.
[abscissas] Intensity of illumination.

Fig. 11. Positive film with tone strip.

Fig. 12. Potassium cell of Elster and Geitel.

Fig. 13. Picture-tonefilm projector.

DEFENDANTS' EXHIBIT NO. 129.

U.S. DISTRICT COURT
M. D. PENN. 129
DEFT. EX. 130

Energieverbrauch.

Die verstärkende Wirkung der Elektronenröhre beruht darauf, daß sie dem Sprechstrom neue Energie zuführt. Da das Gitter lediglich mit jeweiliger Spannung des zu verstärkenden Wechselstromes aufgeladen wird und bei genügend großer negativer Gittervorspannung kein „Gitterstrom" fließt, so ist hier der Energieverbrauch der Röhre praktisch gleich Null. Denn eine Spannung (elektrisches Potential) stellt lediglich eine besondere Art der Energie dar, von der aber in diesem Fall keine Arbeit verlangt wird. Die Schwingungen des Anodenstromes dagegen, die durch die Gitterwechselspannung erzeugt werden, sind verstärkt und können erhöhte Arbeit leisten. Der Verstärkungsgrad einer Elektronenröhre einschließlich eines Transformators ist etwa zehnfach.

Kopplung.

Da eine einzelne Röhre für die Zwecke des Tonfilms meist nicht ausreicht, um eine genügende Verstärkung zu erzielen, so schaltet man größtenteils zwei Röhren hintereinander. Die von der ersten Röhre bereits verstärkten Zeichen werden in der zweiten Stufe auf die erforderliche Lautstärke gebracht. Um die beiden Röhren elektrisch miteinander zu „koppeln", kann man zwei Wege einschlagen. Wenn in die Anodenleitung der ersten Röhre ein Widerstand von hoher Ohmzahl eingeschaltet wird, so kann die an den Enden dieses Widerstandes durch den Sprechstrom erzeugte Wechselspannung unter Zwischenschaltung eines Kondensators dem Gitter der zweiten Röhre unmittelbar zugeführt werden. Diese „Widerstandskopplung" hat den Vorzug, durch völlige Resonanzlosigkeit keine Tonfrequenz gegenüber einer anderen zu benachteiligen und außerdem praktisch verzerrungsfrei zu arbeiten. Allerdings ist der Verstärkungsgrad einer solchen Anordnung nicht besonders hoch, weshalb man meist lieber den Transformator als Kopplungsglied verwendet, der mit zwei Röhren etwa dieselbe Verstärkung erzielt wie ein widerstandsgekoppelter Verstärker mit drei Stufen. Werden die Transformatoren genügend groß dimensioniert, so daß auch bei stärkster Belastung die Grenze der magnetischen Sättigung des Kernes bei weitem nicht erreicht wird, so hält sich die Deformation der Tonwellen in so geringen Grenzen, daß sie praktisch nicht in Erscheinung tritt. Da für den Tonfilm nur große und größte Lautstärken in Frage kommen, so darf das Übersetzungsverhältnis der Transformatoren nicht zu hoch gewählt werden. Man geht im allgemeinen nicht über ein Verhältnis von höchstens 1 : 3 hinaus, da sich sonst Erscheinungen bemerkbar machen, die die Qualität der Wiedergabe stark beeinträchtigen.

Überleitung zum Wiedergabegerät.

Der von der letzten Stufe des Verstärkers kommende Strom besteht aus einem Gleichstrom, der von dem Sprechwechselstrom überlagert wird. Es empfiehlt sich immer, zwecks Erreichung einer besseren Wiedergabe diese beiden Stromarten zu trennen. Und zwar aus folgendem Grunde: Bei elektromagnetischen Lautsprechern ist eine gewisse Vormagnetisierung des Magnetkernes erforderlich, die die Membran des Lautsprechers anzieht und stets unter gewisser mechanischer Spannung hält. Durch den Gleichstromanteil wird diese Spannung aber beträchtlich erhöht und bei den elektrodynamischen Lautsprechern überhaupt erst erzeugt. Es ist klar, daß eine unter starker mechanischer Spannung stehende Lautsprechermembran den Tonschwingungen nicht so gut zu folgen vermag wie eine, die nur lose befestigt ist. Die Verwendung von elektrostatischen Lautsprechern macht die Trennung der beiden Stromarten sowieso zur Bedingung. Man erreicht diese Trennung entweder durch Verwendung eines Ausgangstransformators mit dem Übersetzungsverhältnis 1 : 1 oder einer Wechselstromdrossel in Verbindung mit einem Kondensator höherer Kapazität.

Durch starke Überdimensionierung aller Teile, vor allem der Transformatoren, und durch Verwendung besonderer Schaltungen wird man allen Forderungen, die man heute an einen Verstärker stellen kann, gerecht. Die meist angewendete Gegentaktschaltung verlangt zwar für jede Stufe zwei Röhren, ohne daß gegenüber der gewöhnlichen Schaltung eine erhöhte Verstärkerleistung erzielt wird, doch ist eine verzerrungsfreiere Wiedergabe in jedem Falle festzustellen.

Die Schallwiedergabemittel des Bildtonfilms.

Unter besonderer Berücksichtigung der elektrostatisch erregten Schallstrahler.

Von Hans Vogt.

Physikalisch gesehen, ist der die bisherige Filmindustrie revolutionierende sprechende Film ein Energieumwandlungsvorgang. Die Schallwelle moduliert einen elektrischen Strom, dieser wiederum erzeugt Lichtänderungen. Negativ- und Positivfilm halten diese fest und die Photozelle verwandelt die Helligkeitsschwankungen des Films in elektrische Ströme. Hunderttausendfach im Schallrhythmus verstärkt durchfließen diese die Lautsprecher, gelangen zu den Ohren und zusammen mit dem Bild beeindrucken sie den Besucher des Phonokinos.

Hier sei lediglich vom letzten Glied in diesem Umwandlungsvorgang die Rede, dem Lautsprecher. Welche physikalischen Vorgänge liegen den verschiedenen Systemen von Schallstrahlern zugrunde? Welche besonderen Anforderungen stellt der Bildtonfilm an den Lautsprecher? Welches dieser Systeme hat die meisten Aussichten, zukünftig Verwendung beim Tonfilm zu finden? — Mit diesen Fragen wollen wir uns im nachfolgenden kurz beschäftigen.

Bisher fanden praktisch zwei verschiedene Vorgänge Anwendung, Stromschwankungen in Schall umzusetzen: Änderung des magnetischen Feldes, Änderung des elektrischen Feldes.

Lautsprecherarten.

Auf dem erstgenannten Prinzip basiert der elektromagnetisch erregte Lautsprecher, wie er uns allen, in der Konstruktion ausgehend vom gewöhnlichen Hörtelephon, als Trichter- oder Papierkonuslautsprecher bekannt ist, ferner der elektrodynamische Lautsprecher, bei welchem statt eines schwingenden Eisenkernes eine kleine, mit einem Papptrichter verbundene Spule in einem Magnetspalt schallerzeugend schwingt. Auf Änderung des elektrischen Feldes beruht der elektrostatisch erregte Schallstrahler, auch tönender Kondensator genannt. Bei ihm werden die Anziehungskräfte eines elektrischen Feldes zur Bewegung einer dünnen und großen Membrane benutzt. Man erinnere sich an das Hollundermarkkügelchenexperiment in der Physikstunde.

Anforderungen.

Ein Schallstrahler, wie er im Phonokino zukünftig benötigt wird, muß drei Eigenschaften haben:

Erstens: Er muß praktisch frei von mechanischen Resonanzlagen sein, d. h. möglichst jede Frequenz des menschlichen Hörbereiches proportional der aufgenommenen elektrischen Energie wiedergeben. Es sollen, populär gesprochen, nicht einzelne Töne bzw. Tongruppen immer wieder herausschreien.

Zweitens: Er muß annähernd frei sein von Amplitudenverzerrungen, d. h. jede ihm aufgedrängte Schwingung formgetreu wiedergeben. Gehörmäßig ausgedrückt heißt dies: Er darf nicht klirren und das zu überragende Klangbild nicht mit zusätzlichen, von dem eigenen Schwingvorgang stammenden, unharmonischen Obertönen durchsetzen.

[illegible], Vol. 8, April 27, 1929

Drittens: Er muß einen guten elektroakustischen Wirkungsgrad besitzen und sehr laut sein können unter möglichster Beibehaltung der obigen Eigenschaften. Subjektiv beurteilt heißt dies: Die höchsten und tiefsten Töne muß er dem Ohr rein und ohne unangenehme Beimengungen fullig und lautstark vermitteln.

Bei welchen der vorhin erwähnten drei Erregungsarten besteht nun, physikalisch gesehen, die größte Wahrscheinlichkeit, die eben skizzierten Bedingungen bestmöglich zu erfüllen?

Wer die Aufgabe erfüllen.

Das magnetische System kennen wir. Wir wissen wie schlecht unser Fernsprecher ist, können doch Konsonanten nur durch besondere Kennworte („S" wie Samuel, „F" wie Friedrich) telephoniert werden. Dieses Telephonsystem lag den Trichterlautsprechern zugrunde. Wir sind froh, daß diese schauerlichen Dinger verschwunden sind. Der sogenannte Flächenlautsprecher, ein Papierkonus mit einem ähnlichen oder verbesserten Magnetsystem war, befreit vom Trichterton, schon besser, aber noch immer klang bei diesem die Wiedergabe infolge der schweren Massen des schwingenden Ankers hart und mechanisch. Ihn wird man im Kino nicht aufstellen.

Der elektrodynamische Lautsprecher, der jetzt auch in Deutschland breitere Verwendung

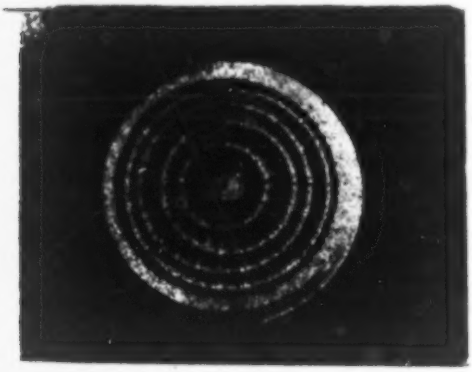

Abb. 1.

findet, ist infolge seiner Anordnung: leichte Spule, unter starken Direktionskräften stehend, in den feinen Ausführungsformen schon vielfach sehr gut. Allerdings klingt er in den meisten Fällen infolge seiner im allertiefsten Gebiet des Hörbereiches liegenden Resonanzlage manchmal in der Wiedergabe dumpf und bollernd. Leicht treten bei ihm auch im Papierkonus Klirr- und Säuselgeräusche auf. Die Haltbarkeit erscheint infolge der starken mechanischen Beanspruchung des Konusmaterials und der wechselnden Einflüsse der Witterung, wie man erst neuerdings erkennt, zweifelhaft. Ob eine Variante des elektrodynamischen Lautsprechers, der Bandhalter, diesen Nachteil weniger besitzt, muß die Erfahrung lehren. Diese Lautsprecher sind zur Zeit, allerdings unter Benutzung besonders orientierter Verstärker, die geeignetsten für den Kinoraum.

Die schwingenden Teile der elektrostatischen Strahler weisen beträchtlich geringere Massen auf als die der magnetisch erregten, ermöglichen infolgedessen eine sehr klare, nuancierte und „durchsichtige" Wiedergabe. Bei diesem Prinzip ist es sehr viel leichter, schwingende Flächen in großem Ausmaße herzustellen, ohne daß die schwingenden Organe mechanisch komplizierte, unharmonische Obertöne ergebende Formen annehmen. Durch die neuerdings von mir angewandte beidseitige Erregung sind die Amplitudenverzerrungen beseitigt. Die spezielle Geeignetheit gerade dieser Anordnung für Tonfilmzwecke macht es erforderlich, daß ich mich hierüber näher verbreite, wobei das allgemeine Interesse, das gerade diesem Wiedergabemittel neuerdings von seiten der am Tonfilm beteiligten Technikern, Künstlern und Unternehmern entgegengebracht wird, es notwendig macht, kurz auf den Werdegang dieser Erfindung einzugehen.

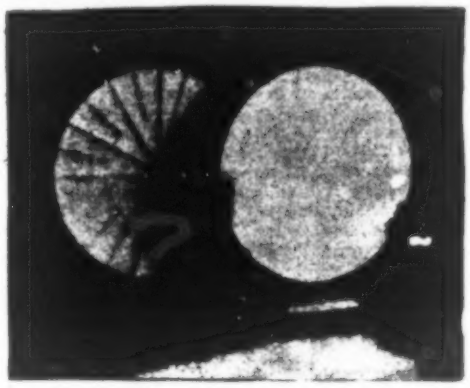

Abb. 2

Entwicklung des elektrostatischen Tonstrahlers.

Als ich 1918, gegen Kriegsende, die verwegene Idee faßte, den Film um die akustische Dimension zu erweitern, das Tri-Ergon gründete, stak die Elektroakustik noch in den Anfänger-Brauchbare Einzelteile, die in ihrer Kombination den tönenden Film ermöglichen, gab es damals noch nicht. Sie wurden gemacht: Kathodophon-Mikrophon, Verstärkerröhren, widerstandsgekoppelter Verstärker, trägheitslose Glimmlampen, Photozellen und Lautsprecher, die Statophone. Ein Statophon zeigt Abb. 1. Es bestand aus einer mit Nuten versehenen Fläche, vor welcher eine versilberte Glimmermembrane, exzentrisch montiert, schwingen konnte.

Mit drei solchen Dingern wurde am 17. September 1922, vormittags 11 Uhr, in dem großen Saal der „Alhambra" in Berlin vor geladenen Gästen ein einstündiges, komplettes Tonfilmprogramm, bestehend aus Prolog, einigen Varieteszenen und dem Drama

Abb. 3

„Der Brandstifter" (von Heyermanns) vorgeführt. Wenn auch die Wiedergabe noch mangelhaft war, das Publikum verstand doch das meiste dieses ersten

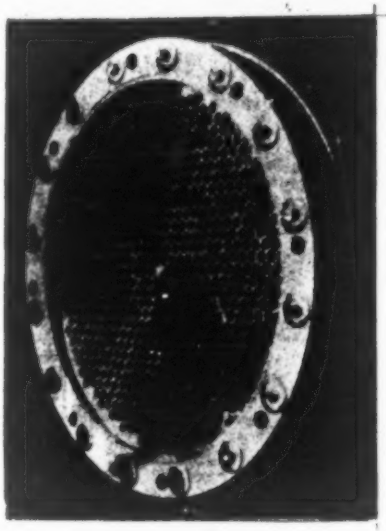

Abb. 4.

reinen Sprechfilmdramas ganz gut und stand stark unter der Wirkung dieses Ereignisses wie auch des Dramas.

In den Jahren 1922—1924 wurde das Tri-Ergon-Verfahren weiter vervollkommnet, auch die Statophone wurden verbilligt, weniger verbessert. Unternehmerischer Unverstand, ablehnende Haltung der Filmindustrie und Mangel an Mitteln lähmten schließlich die technischen Arbeiten ganz.

1926 löste ich mich von meinem an den Folgen der Frühgeburt kränkelnden Kinde los. Griff unter anderem das Kondensatorlautsprecherproblem erneut und — allein an. Ich schuf zunächst ein geeignetes Membranmaterial und machte den Lautsprecher reproduzierbar und reif (nach dem Lautsprecher für Tonfilm verlangte damals noch „niemand) für den Rundfunk. Abb. 2 zeigt einen solchen Lautsprecher geöffnet. Die gespannte, fast unzerreißbare Metallmembrane schwingt als Ganzes vor einer Gitterfläche. Aber was soll der beste Lautsprecher ohne geeigneten Verstärker?

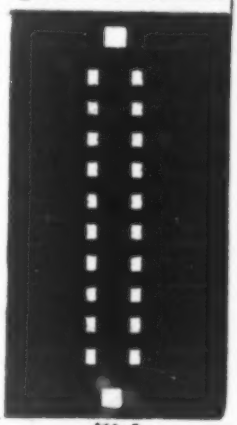

Abb. 3.

Der „Oszilloplan".

1927 schuf ich eine aus Lautsprecher und Verstärker bestehende, vom Lichtnetz gespeiste Einheit für den Radioempfang, das „Oszillophon" (Abb. 3). Feinheit und Durchsichtigkeit der Wiedergabe befriedigten sehr; aber ich wollte auch Fülle und Kraft.

Mitte 1928 begann ich mit Versuchen, die schwingende Membrane von beiden Seiten zu erregen und gleichzeitig auch die Fläche zu vergrößern. Die damit erzielten akustischen Wirkungen waren überraschend gut und ganz außerordentlich erfolgversprechend. Diesen Lautsprecher nannte ich „Oszilloplan", was eine oszillierende, also hin und her schwingende plane Fläche bedeuten soll. Ich verwendete ihn erstmalig in großen Rundfunkempfangs- und Schallplattenwiedergabegeräten, die ich ebenfalls dafür konstruierte und fabrikatorisch herstellen lasse. Ein solches „Oszilloplan" zeigt Abb. 4. Die zwischen zwei geladenen Flächen freischwingende Membrane besitzt bei diesem Modell einen Durchmesser von 30 cm.

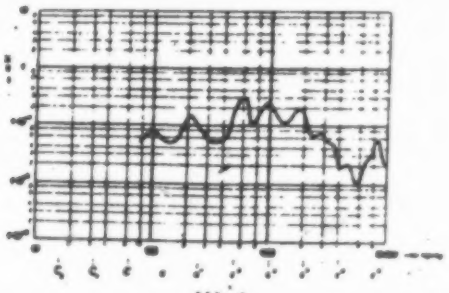

Abb. 6.

Frequenzabhängigkeitskurve des Oszilloplans nach Hans Vogt

Um noch größere Schalleistungen zu erzielen, schuf ich das „Oszilloplan Z", dessen freischwingender Membranteil einen Durchmesser von 400 mm hat und mit welchem Amplituden von $\pm 0{,}2 - 0{,}4$ mm zu erzielen sind, d. h. schon ganz beträchtliche Lautstärken. Die beiderseitig sphärisch ausschwingende Membrane ist, wie die schematische Darstellung (Abb. 5) zeigt, ein sehr einfaches und gleichzeitig durch Luftpolster ideal gedämpftes Schwingungs-

Abb. 7.

gebilde und gibt infolgedessen wenig zusätzliche Kombinationstöne, wodurch selbst bei komplizierten Klanggemischen eine klangreine Wiedergabe gewährleistet wird.

Obwohl die technische Entwicklung, die besonders auch mit Rücksicht auf andere Verwendungsgebiete, auf eine beträchtliche Verbilligung der Herstellung hinzielt, noch nicht völlig abgeschlossen ist, kann schon jetzt positiv gesagt werden, daß das „Oszilloplan" alle diejenigen Eigenschaften besitzt, die es gerade für die Reproduktion von Bildtonfilmen be-

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sonders geeignet machen. Es hat ein außerordentlich breites Frequenzband, wie aus der allerdings an einem 300-mm-Modell gemessenen Kurve (Abb. 6) ersichtlich ist. Zum Verständnis dieser Kurve für Filmleute sei bemerkt, daß als Ordinate der abgestrahlte Schall in Milliwatt, als Abszisse die Frequenz in Hertz, und zwar in logarithmischer Progression aufgetragen ist. Der große Energieanteil in dem sogenannten Formantengebiet des Hörbereiches bei etwa 10000 Hertz illustriert deutlich, daß gerade diese Schallstrahler für Tonfilmzwecke besonders geeignet sind. Tritt doch gerade bei den hohen Frequenzen bei der Registrierung auf dem Filmband aus Gründen, deren Erörterung hier zu weit führen würde, eine prozentuale Amplitudenreduktion auf, die der Tonfilmwiedergabe den bekannten stumpfen und hohlklingenden Charakter gibt. Der tönende Kondensator, wie ich ihn schuf, ist infolge seines Reichtums besonders geeignet, diesen Nachteil zu beheben. Den Schlag der Trommel wie die Obertöne der Sprache und der Violine gibt es gleich gut und stark wieder.

Der elektroakustische Wirkungsgrad erscheint, obwohl genaue Messungen zur Zeit noch nicht vorliegen, weit besser als bei den elektromagnetischen und dynamischen Lautsprechern. Der Moment des Wirkungsgrades wird allgemein noch unterschätzt, er wird aber zukünftig, wenn die Qualitätsprobleme gelöst sind, ganz beträchtlich an Bedeutung gewinnen, da von dem elektroakustischen Wirkungsgrad der Schallstrahler in hohem Maße die Größe der Verstärkerapparatur und damit die gesamten Kosten der Schallerzeugungsanlage im Kino bestimmt werden. Wenn z. B. der Wirkungsgrad des „Oszilloplans" zehnmal besser wäre als der eines elektrodynamischen Lautsprechers (der nur etwa 0,2—0,8 % beträgt), was mit großer Wahrscheinlichkeit vermutet werden kann, so heißt das, daß man bei der Verwendung von tönenden Kondensatoren als Schallerzeuger mit einem zehnmal so kleinen Verstärker die gleiche Wirkung erzielen kann.

In der Abb. 7 zeige ich ein derartiges, in seiner jetzigen Form (zu zwei bis vier Stück parallel geschaltet) für das größte Kino als Schallquelle ausreichendes Instrument im Vergleich zu einer Person. Beral.

Zusammenfassend sei noch das folgende gesagt: Für die Schallwiedergabe im Tonfilmkino ist das beste Wiedergabemittel eben noch gut genug. Soll der Mensch, nachdem der Bildtonfilm seinen sensationellen Charakter verloren hat, weiter noch zufriedener Besucher des Tonfilmkinos bleiben und keine Tonfilmmüdigkeit einsetzen, müssen die akustischen Darbietungen fast die Qualität von Originaldarbietungen erreichen. Eine mit nichtlinearen Verzerrungen durchsetzte kreischende Musik wird trotz zwei Dutzend Lautsprechern und herrlichen Bildern nie zur „Melodie der Welt". Auch die Pferdekräfte der Verstärker tun es nicht. Der Erfolg des Bildtonfilms in Deutschland wird, wenn der Gründungstaumel der Geschäftemacher vorüber ist, eine Angelegenheit hochentwickelter exakter Instrumente sein, die von einem neuen feinfühligen Menschentypus, dem Techniker-Künstler, gehandhabt werden müssen, um lebendiges sinnvolles Geschehen auf dem nunmehr dimensionalen Zelluloidstreifen erfolgreich zu bannen.

Anpassung der Wiedergabemaschinen.

Grundzüge der technischen Erweiterungen in der Projektionspraxis.

Von Dr. H. Joachim.

Unter den verschiedenen Fragen, die den Theaterbesitzer wie den Kinotechniker in bezug auf den Tonfilm heute interessieren, steht die Frage der Wiedergabeapparatur für den Tonfilm mit an erster Stelle. Herrschte über diese Frage noch vor gar nicht langer Zeit selbst unter den Tonfilmfachleuten noch die größte Unklarheit, so ist doch in letzter Zeit auf diesem Gebiete so vieles geklärt worden, daß man technisch die Frage der Wiedergabeapparatur in der Hauptsache als gelöst betrachten kann. Es wird daher sicherlich im Rahmen dieses Sonderheftes von Interesse sein, zu erörtern, was sich heute über die Anpassung der Tonfilmapparate an die Kinowiedergabemaschinen sagen läßt.

Die gebräuchlichen Tonbildsysteme lassen sich nach der Art der Tonaufzeichnung in zwei Gruppen einteilen. Das eine System bedient sich des vertonten Films, das andere des Tonfilms im eigentlichen Sinne. Während bei letzterem die Lautaufzeichnung auf photographischem Wege auf dem Bildband selbst erfolgt, dient bei dem vertonten Film zur Lautaufzeichnung ein besonderer Tonträger, der von dem eigentlichen Bildband getrennt ist. Der gebräuchlichste Tonträger ist die Schallplatte. Weniger verbreitet sind das magnetisierte Stahlband oder ein zweites Filmband mit photographischer Aufzeichnung. Grundbedingung bei allen Einrichtungen dieser Art ist, daß der besondere Tonträger in einer besonderen Apparatur gleichzeitig mit dem Bildband abläuft.

Diese Systeme bedingen infolgedessen die Einrichtung der Synchronapparate, deren verbreitetster und gleichzeitig ältester Repräsentant der Kinoprojektor mit synchronisierter Schallplatte ist („Vitaphone", „Lignose-Hörfilm"). Diese Apparatur stellt eine verhältnismäßig sehr einfache Einrichtung dar, so, man kann sagen, daß gegenüber den älteren Vorkriegskonstruktionen das Problem eigentlich in neuester Zeit noch vereinfacht worden ist.

Während man in früheren Jahren zu umständlichen Synchronisierungseinrichtungen greifen mußte, um die in der Kabine stehende Wiedergabemaschine durch einen an der Wand stehenden Schallplattenapparat zu steuern, wird heute der Drehtisch des Schallplattenapparates unmittelbar durch die Kinotheatermaschine angetrieben, wobei die Kupplung derartig ist, daß Bildband und Schallplatte synchron ablaufen.

Die Methoden der elektrischen Tonabnahme, der Tonverstärkung und der Wiedergabe durch Lautsprecher sind heute so weit durchgebildet, daß sich auf diese Weise eine sehr vollkommene Wiedergabe erzielen läßt, wie man sie im übrigen auch bei modernen elektrischen Schallplattenapparaten, bei Kinomusikapparaten usw. heute allgemein kennt.

Die einzigen Fragen, die bei einer derartigen Synchroneinrichtung auftreten, sind die: Welcher Platz wird dem Schallplattenapparat angewiesen und wie erzielt man genügend gleichmäßigen Ablauf der Schallplatten? Im einfachsten Fall ist die Platzfrage — wie bei Lignose-Hörfilm — derartig gelöst, daß der Drehtisch unmittelbar seitlich vom Projektor gegenüber der Bedienungsseite auf einem besonderen Säulengestell aufgebaut ist und durch eine biegsame Welle oder eine bewegliche Kuppelstange mit einer nach hinten herausragenden Achsen des Projektors gekuppelt wird. Im Falle, daß es sich um einen einzelnen Drehtisch handelt, kann man sich eine einfachere Tonwiedergabeapparatur als diese kaum denken. Der ganze Mechanismus reduziert sich auf ein einfaches Getriebe, das den Plattenteller antreibt. Die Apparatur läßt sich selbstverständlich so einrichten, daß sie an jede Konstruktion des Kinoprojektors angebracht werden kann.

Translation by George C. O. Haas, Ph. D.

[Filmtechnik, vol. 5, April 27, 1929, pages 202-205]

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The Sound-Reproduction Means of the Picture-Tonefilm

with special attention to the electrostatically excited sound-radiator.

By Hans Vogt.

From the point of view of physics, the talking film, which is revolutionizing the hitherto existing film industry, is a process of conversion of energy. The sound-wave modulates an electric current, the latter in turn produces variations of light. The negative film and the positive film retain these, and the photoelectric cell converts the fluctuations in brightness of the film into electric currents. Amplified a hundred thousand times in the rhythm of the sounds, these flow through the loud speakers and reach the ear, and together with the picture they impress the visitor of the tonefilm theater.

Here we shall speak solely of the last member in this conversion process, the loud speaker. On what physical processes are the various systems of sound-radiators based? What special requirements does the picture-tonefilm impose on the loud speaker? Which of these systems has the greatest prospects of being used in the future in connection with the tone film? In what follows we shall deal briefly with these questions.

Hitherto two different processes have been employed in practice for converting fluctuations of current into sound, namely variation of the magnetic field and variation of the electrical field.

Types of loud speakers

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On the first-named principle there is based the electro-magnetically excited loud speaker, as it is known to us all in the form of the horn or paper-cone loud speaker, originating in its design from the ordinary auditory telephone, and furthermore the electrodynamic loud speaker, in which, instead of a vibrating iron core, a small coil connected with a pasteboard horn oscillates, in a manner productive of sound, in a magnet slit. Upon variation of the electrical field depends the electrostatically excited sound-radiator, also called "sounding condenser". In this the forces of attraction of an electrical field are used for movement of a thin and large membrane. Recall the experiment with little balls of elder-pith in the physics class.

Requirements

A sound-radiator such as will in future be required in the tonefilm theater must have three properties:—

In the first place, it must be practically free from mechanical resonance positions, i. e. it must reproduce as far as possible every frequency of the human auditory range proportionally to the electrical energy received. To express it in popular language, individual tones or tone groups should not scream out again and again.

Secondly, it must be approximately free from distortions of amplitude, i. e. it must reproduce with fidelity to form every oscillation which is imposed upon it. Expressed in terms of hearing, this means: it must not rattle and must not interlard the tone picture which is to be reproduced with additional inharmonic overtones which originate from its own oscillatory process.

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Thirdly, it must have excellent electroacoustic efficiency and be able to be very loud with the greatest possible retention of the above properties. Subjectively judged, this means: it must convey to the ear, in volume and with intensity of sound, the highest and the lowest tones, pure and without unpleasant admixtures.

In which of the previously mentioned three types of excitation does there exist, from the point of view of physics, the greatest probability of meeting in the best possible manner the requirements which have just been outlined?

How they meet the requirements

We are familiar with the magnetic system. We know how poor our telephone is, inasmuch as consonants can be telephoned only by means of special identifying words ("S" as in Samuel, "F" as in Frederick). This telephone system constituted the basis of horn loud speakers. We are glad that these dreadful contraptions have disappeared. The so-called surface loud speaker, a paper cone with a similar or an improved magnet system, being freed from the horn tone, was better, but with this, in consequence of the heavy masses of the oscillating armature, the reproduction still sounded hard and mechanical. This will not be installed in the motion-picture house.

The electrodynamic loud speaker, which is now meeting with more extended use in Germany as well, is in many cases very good in the expensive forms of construction in consequence of its arrangement with a light coil subject to powerful directional forces. In most cases, to be sure, in consequence of its resonance position, situated in the very lowest region of the auditory range, it sometimes sounds dull and rumbling in

the reproduction. With it, rattling and buzzing noises also readily arise in the paper cone. In consequence of the pronounced mechanical strain on the cone material and the changing effects of the weather, as has been recognized only recently, the durability appears to be doubtful. Whether a variant form of the electrodynamic loud speaker, the sheet-holder, has this drawback in a lesser degree, experience must show. At the present time these loud speakers, with the use, to be sure, of specially oriented amplifiers, are the most suitable ones for the motion-picture auditorium.

The oscillating parts of electrostatic radiators manifest considerably smaller masses than those of magnetically excited ones, and consequently render possible a very clear, modulated, and "transparent" reproduction. With this principle it is very much easier to produce vibrating surfaces of large area without having the vibrating parts assume mechanically complicated forms giving inharmonic overtones.

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By means of the excitation on both sides which has recently been employed by me the distortions of amplitude are abolished. The special suitability of precisely this arrangement for tonefilm purposes makes it necessary for me to expatiate on it in greater detail, in which connection the general interest which has recently been accorded to just this reproducing means on the part of the engineers, artists, and financial backers participating in the tonefilm renders it necessary to discuss briefly the historical development of this invention.

Development of the electrostatic tone radiator

When, in 1918, toward the end of the War, I conceived of the bold idea of extending the film by adding the acoustic dimension, and established the Tri-Ergon,

electroacoustics was still in its beginnings. Serviceable separate parts which in their combination render possible the sounding film were not as yet in existence at that time. They were created: cathodophone-microphone, amplifier tubes, resistance-coupled amplifier, inertia-free glow lamps, photoelectric cells, and—loud speakers, and statophones. A statophone is shown in Fig. 1. It consisted of a surface, provided with grooves, in front of which a silvered mica membrane, eccentrically mounted, was able to oscillate.

Vogt

With three such contraptions there was presented on September 17, 1922, at 11 a. m., in the large auditorium of the "Alhambra" in Berlin, before invited guests, a one-hour complete tonefilm program, consisting of a prologue, several variety scenes, and the play "Der Brandstifter" ["The Incendiary"]

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(by Heyermanns). Even though the reproduction was still defective, nevertheless the public understood most of this first pure talking-film play very well and was strongly impressed by this event as well as by the play.

In the years 1922-1924 the Tri-Ergon process was further perfected, and the statophones also were made cheaper, not so much improved. Stupidity on the part of financial backers, the refusing attitude of the film industry, and lack of wherewithal ultimately paralyzed the technical operations entirely.

In 1926 I cut loose from my child, which was ailing from the consequences of premature birth. Among other things, I attacked anew—and alone—the condenser loud-speaker problem. In the first place I created a suitable membrane material and made the loud speaker reproducible and fully developed for radio broadcasting (at that time nobody as yet wanted the loud speaker for tonefilm). Fig. 2 shows such a loud

speaker opened. The tensed, almost untearable metal membrane oscillates as a unit in front of a grating surface. But of what use is the best loud speaker without a suitable amplifier?

In 1927 I created a unit for radio reception, the "Oscillophone", consisting of a loud speaker and an amplifier and supplied with current from the electric lighting circuit (Fig. 3). The fineness and transparency of the reproduction were very satisfactory; but I wished to have volume and power also.

The "Oscilloplane"

In the middle of 1928 I began attempts to excite the oscillating membrane from both sides and simultaneously also to increase the surface. The acoustic effects attained thereby were surprisingly good and

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very extraordinarily promising. This loud speaker I named the "Oscilloplane", a name which is intended to denote a plane surface which oscillates, i. e. vibrates to and fro. In the first place I employed it in large radio-receiving and disk-record reproducing instruments, which I likewise designed for it and which I am having manufactured by factory methods. Such an "Oscilloplane" is shown in Fig. 4. The membrane, which oscillates freely between two charged surfaces, has in this model a diameter of 30 centimeters.

In order to attain even greater sound-outputs I created the "Oscilloplane 2", whose freely oscillating membrane portion has a diameter of 400 millimeters and with which amplitudes of $\pm$ 0.2 to 0.4 millimeters, i. e. very considerable intensities of sound, can be obtained. The membrane, which swings out spherically on both sides, is, as the diagrammatic representation (Fig. 5) shows, an oscillation structure which is very simple and at the same time ideally damped by means of air cushions, and it consequently gives few addi-

tional combination tones, as a result whereof a pure-toned reproduction is assured even in case of complicated tone mixtures.

Although the technical development, which, particularly also with an eye to other fields of application, aims at a considerable reduction in the cost of manufacture, is not as yet fully concluded, it can be stated positively, even now, that the "Oscilloplane" possesses all those properties which render it particularly suitable just for the reproduction of picture-

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tonefilms. It has an extremely wide frequency band, as is apparent from the curve (Fig. 6), which was, to be sure, measured on a 300-millimeter model. To make this curve intelligible for film people, we may state that there is entered as ordinate the radiated sound in milliwatts, and as abscissa the frequency in Hertz units, this being done in logarithmic progression. The great proportion of energy in the so-called formant region of the auditory range at about 10,000 Hertz units illustrates clearly that just these sound-radiators are particularly suitable for tonefilm purposes. For just at the high frequencies in the recording upon the film strip, for reasons which it would lead us too far afield to discuss here, there occurs a percentual amplitude reduction which imparts to the tonefilm reproduction the well-known dull and hollow-sounding character. The sounding condenser, such as I created, is, in consequence of its richness, particularly suited to abolishing this drawback. It reproduces with equal excellence and intensity the beat of a drum as well as the overtones of speech and of the violin.

Although accurate measurements are not as yet available at the present time, the electroacoustic efficiency appears to be far better than in the case of

electromagnetic and dynamic loud speakers. The factor of efficiency is in general still underrated, but in future, when the problems of quality have been solved, it will gain very considerably in importance, since it is in great measure the electroacoustic efficiency of sound-radiators that determines the magnitude of the amplifier apparatus and therewith the total cost of the sound-generating installation in the motion-picture

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house. If, for example, the efficiency of the "Oscilloplane" were ten times as good as that of an electrodynamic loud speaker (which amounts to only about 0.2 to 0.8 per cent), as may be conjectured with great probability, than that means that in case of the use of sounding condensers as sound-generators the same effect can be attained with an amplifier which is ten times as small.

In Fig. 7 I show, in comparison with a person, such an instrument, which in its present form (connected in parallel in pairs or in sets of four) is adequate as a source of sound for the largest motion-picture house.

By way of summary the following may be added. For the reproduction of sound in the tonefilm motion-picture house the best reproducing means is just about good enough. If, after the picture-tonefilm has lost its sensational character, people shall continue to remain satisfied visitors of the tonefilm motion-picture house and if a weariness of the tonefilm is not to set in, the acoustic presentations must almost attain the quality of original presentations. Shrill music which is interlarded with non-linear distortions will never become the "melody of the world" in spite of two dozen loud speakers and glorious pictures. Nor will the horse-power of the amplifiers accomplish it. After the frenzy of organizing on the part of the makers of

deals is over, the success of the picture-tonefilm in Germany will be a matter of highly developed exact instruments, which must be handled by a new sensitive type of man, the engineer-artist, in order successfully to register live, sensible action on the celluloid strip, which is now dimensional.

(Wording under Figure 6)

Frequency-dependence curve of the Oscilloplane according to Hans Vogt.

Nummer 32 **1. Beiblatt zum Film-Kurier** Samstag, 6. Februar

M. D. PENN. 130
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Die Idee der Woche:

DER PAPIERFILM

Neuer Versuch auf dem Gebiet der Produktionstechnik

VON FRANK WYSBAR

René Clair sagt in einem Interview einer Tageszeitung über seinen letzten Film „Es lebe die Freiheit", daß er selbst von diesem Film nach der Fertigstellung nicht in allen Teilen befriedigt gewesen wäre . . . er hätte sich manches vorher anders vorgestellt, als es sich ihm nachher in der Vorführung gezeigt hätte.

Clair rührt mit diesen Feststellungen an ein Problem, mit dem ich mich selber seit Jahren auseinanderzusetzen versuche, indem ich mir – wenn während der Produktionen immer wieder die nervenzerfetzende Spannung in den Vordergrund tritt: Wie wird dieser Film von tatsächlich zusammen und im Ablauf wirken? – die Aufgabe stellte, übrig Drob- und Begleitbuch hinaus eine Konstruktion zu schaffen, die, ohne eine Vorwegnahme der Produktion darzustellen, den gedachten Film im Ablauf, im Abrollen zeigt.

Tatsache ist, daß wir uns aus Drob- und Begleitbuchlektüre allein kein rechtes Bild

Ein deutscher Schulfilm

in Frankfurt gezeigt.

Die Klinger-Oberrealschule hat als erste deutsche Schule (fast ohne Geldmittel) einen Film „O freudenvolle Jugendzeit!" hergestellt, der es mit vielen wertvollen Kulturfilmen aufnehmen kann. Der Film zeigt das Leben und Treiben im Landheim der Schule, den inmitten eines idyllischen Dörfchens der Marburger Gegend liegt, den nicht gerade ernsten und sorgenvollen Schulbetrieb während der drei Wochen des Lagerlebens und die mannigfaltigen Freuden und Späße der Jungens und der Lehrer.

Der Star des mit humoristischen Titeln vielleicht etwas überladenen Films ist der Kameramann Diefenbach, ein Lehrer der Schule. Länge des Films 1300 Meter.

machen können, weil unser Hirn einfach nur von einem Drehbuchblatt zum anderen mitliest und mitdenkt und schließlich nur ein ungefährer Eindruck haften bleibt. Tatsache ist ferner, daß in der Produktion die Spannung einsetzt, wie immer dann, wenn man über ein in Arbeit befindliches Produkt „zur endgültig" Beschaid weiß. Aus diesem „endgültigen Wissen" um das Produkt resultieren Unsicherheit, Nervosität, rotlaufen Ohr und Herz – ein „Schwimmen" ist es von der ersten Regieanweisung bis zur Premiere.

Ich behaupte, daß wir Produzenten uns in allgemeinen viel zu schnell auf einen Stoff festlegen, dann wir unrecht verfallen sind, wenn Wissenstrung, Vorstellungen und Erwartungen bereits drehbuchgenau meint geht es Hals über Kopf in die Produktion, weil Termine drängen; die Vorbereitung ist unzureichend – abgehetzt und tatsachen müssen wir zusehen, wie in einer Drehwoche von vierzehn Tagen viele hunderttausende Mark an einem vorgefaßten dahinlaufenden Band in ein Produkt investiert werden, von dessen endgültigem Aussehen wir nur im Vorführungsraum immer wieder was genau überraschen lassen müssen. Der „Schnitt" soll dann retten. Er entsteht so der „zusammenarbeitende" Film.

Um diesem Moment völliger Unsicherheit die Spitze abzubrechen und einen hohen Grad von Wahrscheinlichkeit in die Produktionsvorbereitung und von Sicherheit in die Produktionsdurchführung einzuführen, habe ich den sogenannten „Papierfilm" konstruiert, der im „Papierfilmatelier" in prozisor Vorbereitungsarbeit durch Regisseur, Produktionsleiter, Kameramann und Architekt „verbaubar vorbereitet" werden

Zwischen zwei Lehrrollen, auf denen sich das Papier auf- und abrollt, ist eine breite Zeichenfläche und Leuchtfläche von über 1 m Breite geschaltet, über die in der gleichen Breite das Papier läuft. Auf diesem „Papierfilm" wird einstellungsweise mit Dekorationsentwurf, Kameraeinstellung und grundsätzlicher Darstellerbewegung der Film vorinszeniert. Als besonderes Hilfsmittel dienen hierbei die bereits im Modell aufgebauten Dekorationen, diese sind auf einer großen Fläche aufgebaut, die 1:5 ihren Größenverhältnissen genau mit denen des Ateliers übereinstimmt (Das Modellatelier ist also bereits „vollgebaut").

Ein Elektromotor läßt den Papierfilm, der außerdem noch sämtliche technischen Anweisungen, Zeiten, Längen, Materialverbrauch usw. enthält, langsam vor dem Auge des Beschauers mit allen geplanten Einstellungen, Blenden und Schnitten abrollen, so daß es möglich ist, hier im Papierfilm-Atelier bereits den ersten Rohschnitt auszuführen. Drehbuchabänderungen vornehmen, ganze Szenen umgestalten oder (ein nicht zu unterschätzendes Moment) sich zu der Freudigkeit durchringen, daß der ganze Film überhaupt nicht gedreht werden darf.

Verbindung mit Trickfilmaufnahmen zur Vorbereitung wichtiger Szenen und Zusammenschaltung mit Tonaufnahmen auf Stille-Band oder Daktaphon gestatten weiteren Ausbau des Papierfilms bis zur Projektion auf die Leinwand des Vorführungsraumes.

Ich bin auf viel Kopfschütteln, Skepsis und Ablehnung gestoßen. Nach Besichtigung des ersten Musters aber haben mir Regisseure und Fachleute rückhaltlos ihre Begeisterung darüber ausgesprochen, daß hier ein Weg gefunden scheint, der geeignet ist, eine außerordentliche Ersparnis an Zeit, Material und Drehtagen und außergewöhnliche Erleichterung der Dispositionen zu erreichen.

Nach völliger Fertigstellung des Papierfilms erfolgt sein Zerschneiden in die einzelnen Einstellungen, die nach Ateliers- und Außenaufnahmen, Szenen- und Szenenstellungen gruppiert, die Regiebuch für die praktische Produktionsarbeit abgeben, wie es in solcher Vollständigkeit und Gründlichkeit wohl noch nicht da war. Mag bei dem Einwand gemacht, daß der Regisseur sich eingeengt fühlen wird, wenn er nach einem solchen präzis vorgearbeiteten Plan drehen soll. Ich möchte sagen, daß das Gegenteil erreicht wird: Der Regisseur soll durch vorherige Ueberwindung des technischen Kleinkrams Zeit und Freiheit gewinnen für die rein künstlerische Gestaltung des Produkts. Das ist am ehesten möglich dann, wenn die Arbeit im Papierfilm-Atelier gewissermaßen die erste Rohinszenierung im Kreise der Mitarbeiter gewesen ist, weil auch diese Mitarbeiter jetzt in einer Weise in die Materie und in die Ideengänge des Regisseurs eingeweiht sind, daß eine ganz andere Intensität in der Zusammenarbeit gewährleistet ist als bisher.

Die Debatte um Bolten-Baeckers

Hans Vogt ein „prometheischer" Unternehmertyp

Als alles noch auf das stummen Film schaut, war es Hans Vogt, der den Ton suchte und zu finden wußte. Er war es, der mit anderen sich mit Engel in Berlin zusammenfand, um die ersten Tonfilmversuche zu machen. Er war es, der den Tonfilm in Deutschland geboren hat. Als Ingenieur, als Techniker, als Erfinder. Und als Kaufmann. Er war es, der mit seinen Freunden Engel und Vogt das Tonfilmverfahren ausarbeitete, nach dem Deutschland heute Tonfilme herstellt. Er war es, der mit seinen Freunden Engel und Vogt das Tonfilmverfahren ausarbeitete, nach dem Deutschland heute Tonfilme herstellt. Er war es, der mit seinen Freunden Engel und Vogt das Tonfilmverfahren ausarbeitete, nach dem Deutschland heute Tonfilme herstellt.

In den gesamten Tonfilm-Prozessen, die bisher liefen und noch laufen (vor allem in Amerika) spielen unter den vielen hundert Patenten vor allem drei Patente eine entscheidende Rolle, als deren persönlicher Urheber ich mich bekennen darf:

das Patent Nr. 359 303 vom 14. April 1921, das die prinzipielle Entwicklung schützt;

das Patent Nr. 367 616 vom 22. Mai 1922, das den gleichmäßigen Lauf des Films zum Gegenstand hat;

das Patent Nr. 417 282 vom 5. März 1919, das die Photozelle und tragbaren Lichtquelle schützt.

Diese Patente führten die Klangfilm-Tobis-Gesellschaft und gehören den verbündeten Firmen Klangfilm-Tobis-Amerika. In Amerika besitzt diese Produktion Gebäude für 250 000 sehw. Franken) Millionen Feet und fährt darauf jetzt Prozesse im Werte von vielen hundert Millionen Dollar. Es ist nicht angängig, die erfinderische Arbeit, als deren Ergebnis diese Patente entstanden, und das deutsche Patentamt bestätigt seiner Prüfung zu verdanken, wie es Bolten-Baeckers getan hat. Das Entwicklungspatent ist das Ergebnis einer langen Untersuchungsreihe auf Wahrung der Proportionalität zwischen Negativ und Positiv, das Schwingungs-Patent die Folge eingehender Studien über die Gleichmäßigkeit des Filmdurchlaufes, und das Photozellen- und Glimmlampen-Patent über die jeweiligen prinzipiellen physikalischen Vorgänge enthalten, die für befriedigendes Aufnehmen und Wiedergeben von Schallvorgängen auf Filmbändern unbedingt sind.

Die Erfinder selbst durch ihre Leistungen der Allgemeinheit, deren Erfindungen verdienen diesen Schutz, aber es wäre wünschenswert, der Machtcharakter dieses Schutzes in seinen Grundsätzen, als ohne Erfindung von allgemeinem Interesse nicht an einem Objekt kapitalistischer Spekulationen herabgewürdigt werden dürfte. Die Entwicklung der sperrenden Filme innerhalb der Tri-Ergon-Gemeinschaft hat 10 000 RM. gekostet. Dieses Geld zu verzinsen, den Erfindern und Kapitalisten, die die Versuche fit zu ersten, eine kleine Rente zu gewähren, wäre ein leichtes gewesen und gerecht. Die deutsche Filmindustrie hat sich selbstverständlich abklärig und vorsichtig verhalten, nicht um diese Angelegenheit gebührend zu würdigen. Ein Aufsichtsrat (und Schutzlast) hat sich in den Besitz der Patente gesetzt und ausländische Gesellschaften von rd. 40 bis 60 Millionen Gulden um diesen Kreuzer herum gegründet. Man mache sich klar, daß die Verwertung dieser Summen, über deren Verbleib es einmal interessant wäre, Näheres zu hören, in erster Linie den beiden Erfindern gebührt.

Ton-Bildaufnahmen auf gleichen Filmmaterial

Beendigung zur Kopienfrage.

Der klärende Vortrag von Bolten-Baeckers, den das Hauptinteresse Deutschlands diesem Werke weist, hat, wie gesagt, viele Hindernisse aus dem Wege geräumt, die unserem restlosen Absetzungen noch entgegen standen.

Für heute beginnen wir zunächst ohne kommentierende Anmerkungen mit Lizenz-Bedingungen.

Wir lassen mit Interesse die Ausführungen des Herrn Bolten-Baeckers.

Die Darstellung, die Herr Bolten-Baeckers von der Gesamtsituation gibt, bringt zusammenfassend das ja mit wenigen Worten bekannten Komplex der Fragen um die Patentschutzrechte für den Tonaufnahmeverfahren.

Wie Herr Bolten-Baeckers auch [illegible] ist das Entwicklungs- und Kopierpatent wohl auch der strittigste Punkt des Problems der Tobis.

In der Darstellung des Herrn Bolten-Baeckers möchten wir [illegible] ergänzende technische Ausführungen zur Verfügung stellen.

Herr Bolten-Baeckers schreibt, daß er gegenüber, sei auf die Begründung des Klangfilm-Patentes „Entwicklung von Bild- und Ton-Negativen auf gleichem Rahmen bei gleicher Entwicklungszeit sei ein getrenntes Verfahren". Bei allen Fehlern in der Praxis vorgekommenen Fällen, in denen dieser Punkt strittig war (z. B. Salamander-Prozeß), hat es sich, wie Herr Bolten-Baeckers allerdings nicht näher ausführt, um Arbeiten mit verschiedenem Material für Aufnahme von Ton und Bild gehandelt. Ob ein solches Verfahren unter das Entwicklungspatent fällt, sei dahingestellt, doch wurde, wie die erfüllten Prozesse ergeben, auch seitens der Tobis die Anwendbarkeit des Tobis-Patentes für diesen Fall bezweifelt.

Das Tobis-Patent der getrennten Behandlung kommt heute noch Anwendung gelegentlich Bedeutung für Fortfall, sobald man für die Aufnahme dasselbe Material für Bild und Ton verwendet und die Ton- und Bildaufnahmen, wie auch Herr Bolten-Baeckers schon richtig darstellt, im gleichen Entwicklungs- und Kopierverfahren behandelt. Hierdurch wird auch der etwaige Einwand, daß bei Verwendung verschiedener Emulsionen der Entwicklungsvorgang zum Teil in die Emulsion verlegt und so trotz gleicher Entwicklungsdauer eine verschiedene Entwicklung erzielt wird, entkräftet.

Die Arbeiten, die wir in den letzten Monaten mit unserem Braunschen-Rohr-Aufzeichnungs-System weiterverführt haben, führten zu dem Ergebnis, daß der Lichtverbrauch unserer Apparatur für die Tonaufzeichnung etwa so große ist zweitens größer als bei den mit anderen Aufzeichnungsverfahren arbeitenden, zweifellos ausgenutzteren Verfahren, daß der Verwendung des gleichen Materials für die Ton- und Bild-Aufnahme nichts mehr im Wege steht.

Wir sind daher der Ueberzeugung, daß der Verwendung von Tonfilmen nach demjenigen Verfahren das Entwicklungspatent die Tobis nicht entgegensteht.

Wir erwähnen noch, daß wir glauben, daß für die Beurteilung der Gesamtlage auch noch für die Stellungnahme der Produktion zu den schwebenden Fragen das Gemeinschaftsverfahren der vorgenannte Punkt von wesentlicher Bedeutung sein könnte.

Chronik der Uraufführungen 3.

Skandinavien.

1. Januarwoche:

Helsingfors: „Tiroler Bauernsohn heraf" (Die Bauern des Hochgebirges). Produktion: Suomi Filmi, Helsingfors. Regie: Dir. Erkki Karu. Hauptrollen: Helena Koskinen, Emil Virta, Sangerpaar. Einzelnes: Volkstrachten, Wandervolk Naturaufnahmen. Censur Erlaubt.

2. Januarwoche:

Stockholm: Hjalmar till Hjorsberga" (Auf hohem Berge vom Hjalmar). Produktion: Filmindustri, Stockholm. Regie: Gustaf Edgren. Hauptrollen: Edith Erastam, Elisabeth Frisell und Karin Swanström.

Helsingfors: „Kalevan soi Helmi". Liebesdrama aus Finnland. Hauptrollen: O. V. Saarinen, Vilma Pohjanpää und Ida Koskenniemi. Einzelnes: Volkstrachten aus dem Leben der Karelier in Finnlands Grenzgebieten. Viele lustige Volksszenen mit Tanzbelustigungen.

3. Januarwoche:

Stockholm: Hans Nes gestalt: „Das Lied seines Lebens". Produktion: Filmindustri, Stockholm. Regie: Per Lindberg. Hauptrollen: Björn Berthelson, Telegraf, Hakon Westergren, Sigurd Wallen, Carl Barcks und Nina Lundahl. Szenerie: Norwegische Landschaften, Norwegen und das Polarmeer. Einzelnes: Eisbrecher, Dampfer, Fischerboote, Meer der Eisberg, Fischer.

Translation

from the Film-Kurier of February 6, 1932.

The debate about Bolten-Baeckers.

Hans Vogt

a "prominent" disinterested party.

At a time when everybody was still swearing by the silent film (1919), it was Hans VOGT who had the courage not only to believe in the sound film but also to carry it out in practice. He joined with Engel and Massolle, sacrificed his position and savings to solve the problem of the sound film. We know that the three inventors were successful. On September 17, 1922 the first one hour sound picture program was demonstrated at the Alhambra at Berlin, using the same method as is still used at the present time by Tobis. We know the unhappy story of this inventor complex.

In a long important document, the general part of which we have for the time being eliminated for reasons of economy of space, Hans VOGT says as follows:

"In the entire sound picture suits which have heretofore been conducted and are still being conducted (above all in the U. S. A.), among many hundreds of patents three patents above all play a deciding role and of which I can call myself the personal inventor:

the Patent 368,383 of April 14, 1921 which protects the separate development,

the Patent 387,058 of May 22, 1920 which has as its subject matter the uniform motion of the film,

the Patent 417,967 of March 3, 1919 which protects the photo-electric cell and the inertialess source of light.

These patents led to the agreement between Klangfilm and Tobis and impart to the combined companies

the character of a monopoly. In the United States these patents (bought for 200,000 Swiss franks) are owned by William Fox, and he is now conducting suits thereupon in the value of many millions of dollars. It is not permissible that the inventive work as a result of which these patents were created, and the German Patent Office with respect to its examination, be ridiculed as is done by Bolten-Baeckers. The developing patent is the result of a long series of experiments to protect the proportionality between positive and negative, the flywheel patent the result of detailed studies with respect to the uniformity of the film transport, and in the photo-electric cell and glowlight patent those principal physical proposals are contained which are decisive for inertialess recording of sound frequencies upon strips of film.

An inventor by his efforts serves the general public. His inventions deserve a protection, but it would be desirable to alter the legal character of such protection so that an invention of general interest is not degraded into an object for capitalistic speculation. The development of the talking film within the Tri-Ergon group has cost 60.000 Reichsmark. To give interest on this money and to allow a small profit to the inventors and capitalists who financed these experiments would have been a simple matter and been equitable. The German film industry at this time with its old wisdom and prejudices did not interest itself in this matter. An outsider (and speculator) obtained possession of the patents and formed foreign companies of a capital of about thirty to forty million gulden. It should be made clear that the interest on these sums, as to the whereabouts it would be interesting to hear more details, is what primarily causes the high royalties.

Elektrotechnische Zeitschrift. 1922. Heft 52. 28. Dezember 1922.

...schäden nur ausnahm... sie so einfach, wie dies in dem eingangs erwähnten Aufsatz ... gestellt ist. Daß der Trennungsstrich zwischen beiden Arten von Schäden zwischen dem beschädigten Objekt und seiner Umgebung liegt, widerspricht nicht nur den Vereinbarungen zwischen den beteiligten Interessentengruppen, sondern beseitigt auch in vielen Fällen den Zweifel deshalb nicht, weil elektrische Maschinen und Apparate häufig in direkter Verbindung miteinander stehen. So würde z. B. die Frage auftreten, ob ein Drehstromgenerator mit seiner Erregermaschine, oder ob ein Motorgenerator als Maschineneinheit zu betrachten ist, oder an welcher Stelle ein Generatorbrand, der sich durch den Kabelgraben auf die Schaltwand übertragen hat, anfängt, ein Brandschaden zu sein, wenn er durch Kurzschluß herbeigeführt wurde. Mit Recht sind daher andere Kriterien als diese rein äußerlichen als maßgebend für die Trennung beider Arten von Schäden vereinbart und praktisch im Gebrauch.

Berlin, 10. XI. 1922. Dr. Müllendorff.

Erwiderung.

Auf obiges habe ich zunächst zu erwidern, daß der befragte Aufsatz in der „Feuerversicherungs-Zeitschrift" für Nichttechniker bestimmt war und daher nur einen skizzenhaften Überblick über die bezüglichen Verhältnisse geben, nicht aber diese selbst erschöpfend behandeln sollte. Das gilt also hierbei auch bezüglich der Tragweite einer Betriebsschadenversicherung, auf deren Formulierung im einzelnen ich daher auch nicht eingegangen bin. Auf die Möglichkeit eines Versagens einer solchen Versicherung im Einzelfalle, z. B. bei völliger Außerachtlassung des notwendigsten Schutzes gegen böswillige Beschädigung usw., glaube ich aber doch wohl nicht mit Unrecht hingewiesen zu haben, da sonst doch starker Mißbrauch mit einer solchen Versicherung getrieben werden könnte, oder aber die Versicherungskosten sehr hohe werden müßten. Das schließt allerdings nicht aus, daß auch Versicherungsverträge von der Tragweite wie sie Herr Dr. Müllendorf bezeichnet, geschlossen werden können.

Die Abgrenzung von Betriebsschäden und Feuerschäden ist von mir ebenfalls nur am Beispiel eines einfachen Falles angegeben worden, im übrigen ist aber nicht verhehlt worden, daß hier die Grenze zwischen Betriebs- und Feuerschaden oft versteckt liegen würde, weshalb ja auch aus diesem Grunde die doppelte Versicherung noch einmal besonders empfohlen wurde. Durch nähere Angabe der z. Z. hierbei ... Kriterien hätte sich Herr Dr. Müllendorf den Dank der interessierten Leser sichern können. Von mir aus halte ich die Angelegenheit hiermit für erledigt.

Breslau, 1. XII. 1922. A. Herrmann, Betriebsdirektor.

DEFT. EX. 131

Tönender Film.

Auf S. 1305 berichtet Herr Dr. Nesper in einem Artikel „Tönender Film" über den bisherigen Stand der Arbeiten auf dem Gebiete der Tonfilmtechnik. Der Inhalt dieses Artikels zwingt mich zur Steuer der Wahrheit und im Interesse der Erfinderehre der Herren Vogt, Masolle und Dr. Engl in dieser Form Aufklärung von Herrn Dr. Nesper zu verlangen. Herr Dr. Nesper erwähnt in dem Artikel Veröffentlichungen von Gaumont, Simon und Ruhmer. Ferner erwähnt er Arbeiten von de Forest und Langmuir. Endlich behandelt er ausführlich Lösungen, die nach seiner Behauptung Herr G. Seibt angegeben hat. Dagegen erwähnt er mit keinem Wort die Tatsache, daß am 17. IX. 1922 eine Uraufführung sprechender Filme stattgefunden hat, die auf den Arbeiten der Herren Vogt, Masolle und Dr. Engl beruht. Diese Aufführung ist Herrn Dr. Nesper nicht unbekannt geblieben, denn er ist selbst anwesend gewesen. Er hat also durch eigenen Augenschein feststellen müssen, daß hiermit zum ersten Male im Gegensatz zu der vielfältigen Literatur über die tönenden Filme, die er erwähnt, der tönende Film in die Wirklichkeit übergeführt und eine technische Lösung gegeben worden ist. Er erwähnt auch nicht die Namen der Erfinder, obwohl ihm ein Programm übergeben wurde, aus dem er die näheren Angaben über die Art der Lösung des Problems dieser Erfinder in großen Zügen entnehmen konnte. Er übergeht die zahlreichen Veröffentlichungen, die vor Erscheinen seines Berichtes in fast allen deutschen Zeitungen und Fachzeitschriften über die Vorführung erschienen sind. Er übergeht endlich die vielen bisher veröffentlichten Patente der Herren Vogt, Masolle und Dr. Engl, die ihm als Patentfachmann sicherlich nicht unbekannt geblieben sind und aus denen er ohne weiteres entnehmen konnte, worin die von den genannten drei Erfindern gegebene Problemlösung besteht.

Alles das ist erstaunlich, noch erstaunlicher aber ist die Tatsache, daß er eine Reihe wichtiger, von den drei Erfindern herrührender Gedanken als geistige Erzeugnisse des Herrn Dr. Seibt wiedergibt. Zur Feststellung des Tatbestandes richte ich daher folgende Fragen an Herrn Dr. Nesper:

1. Dr. Nesper behauptet: „Die erste bekannt gewordene Lösung rührt von Georg Seibt (1918) her." Hat er oder ein anderer bis heute eine von Seibt stammende Lösung gesehen und gehört? Wo ist sie „bekannt geworden"?
2. Auf welche Tatsachen stützt Dr. Nesper seine Behauptung, daß Seibt die dünndrähtige Glühlampe zur Fixierung der Schallfrequenzen zuerst angegeben hat?
3. Wann und wo hat Dr. Seibt die Gehrckesche Glimmlichtröhre für Tonfilme vorgeschlagen?
4. Wann und wo hat Dr. Seibt eine stickstoffgefüllte kapillarförmige Glimmlichtröhre für den gleichen Zweck vorgeschlagen oder benutzt?
5. Wann und wo hat Dr. Seibt die photoelektrische Zelle für den sprechenden Film vorgeschlagen oder benutzt?
6. Wann hat Dr. Seibt das an sich bekannte elektrostatische Telephon für Zwecke des sprechenden Films in Vorschlag gebracht? Wann und wo hat Seibt diese Anordnung zum ersten Mal aus- oder vorgeführt?
7. Auf welche Feststellungen stützt Dr. Nesper seine Behauptung, daß „im Prinzip von allen Erzeugern tönender Filme z. Z. die auf Ruhmer fußenden, von Dr. Seibt zuerst für die Technik angegebenen Fundamentalanordnungen ... geführt werden"?
8. Warum erwähnt Dr. Nesper nicht in seinem Bericht auch er Tonfilme gesehen und gehört hat, die von den Erfindern stammen?
9. Warum fehlt in dem Bericht Dr. Nespers jeder Hinweis darauf, daß die erste praktische Lösung von den drei Erfindern vor gut 4½ Jahren begonnen und in einem vielseitigen Programm öffentlich erstmalig vorgeführt wurde?

Berlin-Tempelhof, den 10. XI. 1922. C. R. Forth.

Erwiderung.

Herr Forth „verlangt" die Beantwortung von neun Fragen. Die ersten 7 Fragen finden ihre Beantwortung bereits in meinem Aufsatz selber. Die von Dr. G. Seibt angegebenen Einzelapparate, mit deren Hilfe die Lösung des tön... den Films im wesentlichen in der von dem genannten Laboratorium bewirkten Anordnung erzielt wurde, sind seit 1918, einige auch etwas später in der Firma Dr. G. Seibt in Berlin-Schöneberg, Hauptstraße 9, entstanden und wurde mir daselbst gezeigt. Auf diese Weise habe ich die Seibtschen Erfindungen kennen gelernt und mit Interesse weiter verfolgt.

Die Fragen 8 und 9 beziehen sich auf die Leistungen bzw. Vorführungen des Laboratoriums Vogt, Masolle, Dr. Engl. Die von Herrn Forth behauptete Tatsache, daß eine tönende Filmvorführung von den Genannten in der Alhambra am 17. IX. 1922 stattgefunden hat, ist zutreffend. Desgleichen auch, daß ich dieser Vorführung beigewohnt habe. Hingegen ist es aus dem überreichten Programm wirklich nicht zu ersehen, mit welchen Mitteln der tönende Film der 3 Genannten erzielt wird. Das Programm enthält in einem allgemein feuilletonistisch gehaltenen Stil nur Andeutungen der benutzten Mittel. Dagegen keine für den Fachmann allein in Betracht kommende exakte Darstellung. Ich habe daher absichtlich vermieden, in meiner Arbeit in der „ETZ", mangels jeglicher wirklicher Unterlagen auf die Arbeiten der 3 Herren technisch einzugehen. Ich hätte lediglich den ästhetischen Eindruck der Vorführung schildern können, wofür aber die Spalten der „ETZ" bisher nicht zur Verfügung standen. Ich stehe durchaus nicht an, zu erklären, daß das Mikrophon-Telephon, wenn es einmal gelungen sein sollte, es technisch so zu verbessern, daß es einwandfrei arbeitet, einen tatsächlichen Fortschritt darstellt. Zurzeit kann ich dies billigerweise bezweifeln, da es selbst in der Alhambra-Vorführung nicht gelungen war, einen einwandfreien Wiedergabe- bzw. Verstärkungseffekt zu erzielen. Die Anordnung „kippte" bisweilen in bedenklicher Weise, so daß die im übrigen recht mäßigen Gesangsvorträge einen für das Ohr häufig peinlichen Eindruck hervorriefen. Instrumentale Musik, das Bellen eines Hundes, waren unter Beibehaltung eines durchaus grammophonartigen Charakters verhältnismäßig am besten. Die menschliche Sprache war meist ganz unverständlich.

Dies alles bedeutet selbstverständlich verhältnismäßig wenig, da ja durch die Vorführung nur ein Anfang gemacht werden sollte. Es ist durchaus zu erwarten, daß auch die 3 Herren mit der Zeit bessere Resultate erreichen werden. Allerdings bezweifle ich, daß unsere Kinoräume, welche nur nach optischen Gesichtspunkten gebaut sind, sich überhaupt für derartige Vorführungen besonders eignen. Vielleicht ist es aber möglich, z. B. durch Benutzung der Johnsen-Rahbeck-Anordnung der Huth-Gesellschaft, welche einen höheren Grad der Vervollkommnung erreicht zu haben scheint, wesentlich bessere Resultate für den Kinoraum zu erzielen.

Es erscheint mir als wenig glücklicher Gedanke von Herrn C. R. Forth, auf die Patentanmeldungen in seinem obigen Angriff besonders hinzuweisen. Das Programm stellt allerdings mit Stolz fest, daß etwa 160 deutsche und 300 Auslandspatente erforderlich waren, um den gewerblichen Rechtsschutz zu erlangen. Wenn man sich die Patente jedoch vornimmt, so erkennt man das Überwiegen der Quantität gegenüber der Qualität und man erstaunt eigentlich nur über die außerordentliche Schreibarbeit, die hier geleistet wurde. Ich kann z. B. beim besten Willen eine große Erfindung nicht darin erblicken, wenn im Jahre 1920 die Benutzung eines Schwungrades zum Patent angemeldet wird, um den Gang

eines Mechanismus gleichförmiger zu gestalten. Dies ist nur ein Beispiel unter vielen.

Ich hätte es für richtiger gefunden, statt die Arbeiten anderer anzugreifen, den tönenden Film so auszubilden, daß er für die praktische Ausführung wirklich in Betracht kommen kann.

Berlin, 5. XII. 1922. Dr. Eugen Nesper.

Zur Theorie der Stromwendung.

Zu dem Aufsatz in Heft 44, S. 1288 bemerke ich, daß auch ich in einem in „Elektrotechnik und Maschinenbau", Jahrgang 1922, Heft 16, erschienenen Artikel darauf hingewiesen habe, daß die ablaufenden Bürstenkanten zweckmäßig keine Zylindererzeugende sein sollen. Die Ungenauigkeit der Werkstatt sorgt jedoch in der Regel schon dafür, daß hierzu keine besonderen Maßnahmen erforderlich sind. Ein im Prüffeld der A. E. G. im Jahre 1907 vorgenommener Versuch mit Bürsten mit schwach gekrümmter Ablaufkante ergab keinen merkbaren Vorteil gegenüber der gewöhnlichen Ausführung.

Berlin-Niederschönhausen, Platanenstraße 10, 9. XI. 1922. Wilh. Weiler.

LITERATUR.

Besprechungen.

Betriebskosten und Organisation im Baumaschinenwesen. Ein Beitrag zur Erleichterung der Kostenanschläge für Bauingenieure mit zahlreichen Tabellen der Hauptabmessungen der gangbarsten Großgeräte. Von Dipl.-Ing. Dr. Georg Garbotz. Mit 23 Textabb. 126 S. in 8°. Verlag von Julius Springer, Berlin 1922. Grundzahl 3,6.

Rationalisierung der Betriebe, so lautet heute die Forderung des Tages. Mehr denn je gilt es, mit geringstem Aufwand größtmögliche Leistungen zu erzielen, was im Hinblick auf den Wiederaufbau ganz besonders für das Baumaschinenwesen zutrifft. Das vorliegende Büchlein stellt sich die Aufgabe, hier richtunggebend zu wirken, und beantwortet eine Reihe von Fragen, welche vom Bauingenieur bei der Ausarbeitung der Kostenanschläge stets von neuem gestellt werden: Welche Abmessungen und Leistungen müssen die Geräte haben, was kostet der Maschinenbetrieb, wie lassen sich die Kosten auf ein Mindestmaß zurückführen usw.? In den einzelnen, durch wertvolle Tabellen ergänzten Kapiteln macht der Verfasser Angaben über die Betriebskosten der Kessel, Lokomobilen, Diesel- und Benzolmotoren, der Elektromotoren und Generatoren, Betonmischmaschinen, Steinbrecher, Dampf- und Kreiselpumpen, Kompressoren, Bagger, Rammen, Krane, Lokomotiven, Kraftwagen, Dampfer, Straßenwalzen usw., wobei alle Ziffern auf Friedensverhältnisse bezogen werden. Doch dürften sich daraus, unter Berücksichtigung der wirtschaftlichen Zusammenhänge und unter Zugrundelegung von Preissteigerungsfaktoren, auch die gegenwärtigen Kosten ermitteln lassen, die allerdings bei der von Tag zu Tag sich ändernden Marktlage nur als Momentanwerte aufzufassen sind. Eine Anzahl weiterer Kapitel ist der Organisation sowie der Betriebskontrolle und ihrem Einfluß auf die Kosten des Betriebes gewidmet. Um ein Bild von den Erfolgen einer solchen Kontrolle zu geben, führt der Verfasser die folgenden von einem Bauingenieur festgestellten Ölverbrauchszahlen einer Tunnelbaustelle an, in der eine 170- und zwei 100-pferdige Lokomobilen standen. Vor Einführung der Kontrolle betrug der Verbrauch je Betriebsstunde 1275 g Zylinderöl und 1371 g Maschinenöl, nach ihrer Durchführung und sorgsamster Ölbewirtschaftung 168 g Zylinderöl und 280 g Maschinenöl; somit wurden in den 6000 Betriebsstunden bis zur organisatorischen Neuordnung 6900 kg Zylinderöl und 4190 kg Maschinenöl vergeudet! Besonders hervorgehoben sei der Hinweis des Verfassers auf die großen Vorzüge des elektrischen Antriebes im Baumaschinenwesen. Der Elektromotor sollte in noch ganz anderem Maße sich auf den Baustellen Eingang verschaffen wie bisher, zumal hier durch Benutzung von Zählern und registrierenden Meßinstrumenten die Möglichkeiten einer eingehenden Betriebskontrolle geradezu ideal sind. Das Garbotzsche Büchlein stellt sicherlich einen wertvollen Beitrag zur Erleichterung der Kostenanschläge des Bauingenieurs dar, und wenn der Verfasser im Verwort die Absicht äußert, die vorliegende Arbeit im Bedarfsfalle zu einem Handbuch über den Baumaschinen zu erweitern, so dürfte die baldige Ausführung seines Planes nur zu wünschen sein. Ruegg.

Eingänge.

(Ausführliche Besprechung einzelner Werke vorbehalten.)

Bücher.

Handbuch der Deutschen Aktien-Gesellschaften. Ein Hand- und Nachschlagebuch für Bankiers, Industrielle, Kapitalisten, Behörden usw. Nebst einem Anhang, enthaltend: Deutsche und ausländische Staatspapiere, Provinzial-, Kreis- und Prämien-Anleihen, Pfand- und Rentenbriefe, ausländische Banken, Eisenbahn- und Industrie-Gesellschaften. Jahrbuch der deutschen Börsen. Begründet von Robert Thieme. 27. umgearb. u. verm. Aufl. Ausg. 1922/1923. Bd. I. CLXVII u. 1067 S. in 8°. Mit einem Anhang mit 700 S. Verlag für Börsen- und Finanzliteratur A. G., Berlin u. Leipzig 1922.

Taten der Technik. Ein Buch unserer Zeit. Von Hanns Günther. Mit Beiträgen von Arthur Fürst, Dipl.-Ing. E. Laßwitz, Dr. L. Richters, Dipl.-Ing. K. Stern, Dr.-Ing. P. Schuster u. a. In 20 Lieferungen mit 20farbigen Tafeln, 40 Porträts und über 500 Bildern im Text. Verlag von Enscher & Co. A. G., Leipzig 1922. Erschienen: Lieferung 1 bis 3.

[Der Verfasser hat sich die Aufgabe gestellt, die technischen Glanzleistungen der Neuzeit in Wort und Bild allgemein verständlich zu schildern. In den vorliegenden ersten 3 Lieferungen wird der Werdegang der Lötschbergbahn mit den vorangehenden politisch-wirtschaftlichen Kämpfen, ein modernes Eisenwalzwerk, die Technik im Dienste der Astronomie und die Taschentechnik von ihren Anfängen bis zum heutigen Entwicklungsstande behandelt. Das allgemein verständlich abgefaßte und mit reichem und prächtigem Bildschmuck versehene Werk wird sich viele Freunde erwerben.]

Zur revolutionären Gewerkschaftsbewegung in Amerika, Deutschland und England. Eine vergleichende Betrachtung. Von Dr. sc. pol. Hans Böttcher. „Probleme der Weltwirtschaft". Schriften des Instituts für Weltwirtschaft u. Seeverkehr an der Universität Kiel. Herausgegeb. von Prof. Dr. Bernhard Harms. Bd. 37 XIV u. 236 S. in 8°. Verlag von Gustav Fischer, Jena 1922.

Die Reparaturen an elektrischen Maschinen, insbesondere die Herstellung der Ankerwicklungen an Gleich- und Drehstrommotoren, Kollektorbau; Fehlerbestimmung und Prüfung elektrischer Maschinen, Revision elektrischer Kraftanlagen. Von Ing. Fritz Raskop. 3. Aufl. Mit 123 Textfig. IV u. 233 S. in 8°. Verlag von Hermann Meusser, Berlin 1922.

Werkstattansiedlung. Untersuchungen über den Lebensraum des Industriearbeiters. Von Dr. jur. Eugen Rosenstock in Verbindung mit Eugen May u. Dr. jur. Martin Grünberg. (Bildet Bd. 2 der Sozialpsychologischen Forschungen des Instituts für Sozialpsychologie an der Techn. Hochschule Karlsruhe. Herausgegeb. von Prof. Dr. phil. et med. Willy Hellpach.) — 292 S. in 8°. Verlag von Julius Springer, Berlin 1922. Grundzahl 6.

Entscheidungen des Reichsgerichts. Herausgegeb. von den Mitgliedern des Gerichtshofes und der Reichsanwaltschaft. Bd. 104. Entscheidungen in Zivilsachen. Mit Anhang: Entscheidung des Staatsgerichtshofs. XVI u. 463 S. in 8°. Verlag Vereinigung wissenschaftlicher Verleger, Walter de Gruyter & Co., Berlin u. Leipzig 1922.

La radiotéléphonie. Von Carlo Tochè. Mit 44 Abb. VI u. 95 S. in 8°. Verlag von Gauthier-Villars et Cie., Paris 1922.

La force motrice électrique dans l'industrie. Von Eugène Marec. Mit einem Vorwort von Paul Janet. Mit 541 Abb. VIII u. 514 S. in 8°. Verlag von Gauthier-Villars et Cie., Paris 1922.

Electriciteitsvoorziening. Ein Hochspannungs-Freileitungsnetz für Niederland zur Speisung der interkommunalen 10000 Volt-Verteilungsnetze und zur Verbindung der stromliefernden Zentralen. 7. Teil. Von der Vereinigung der Direktoren der Elektrizitätsbetriebe in Niederland. Mit 42 Abb. u. 18 Taf. 130 S. in gr. 8°. Verlag von P. N. van Kampen & Zoon, Amsterdam 1922.

Maschinenbau und graphische Darstellung. Einführung in die Graphostatik und Diagrammentwicklung. Von Dipl.-Ing. W. Leuckert u. Dipl.-Ing. H. W. Hiller. 2. verb. u. verm. Aufl. Mit 72 Textabb. u. 2 Tafeln. VI u. 90 S. in kl. 8°. Verlag von Julius Springer, Berlin 1922. Grundzahl 1,8.

„Beiblätter zu den Annalen der Physik". Herausgegeb. von E. Wiedemann bis 1900, Walter König bis 1907, Friedrich Pockels bis 1913 u. F. Harms bis 1919. Register zu Band 31—43 (1907—1919). Von Ing. W. Strobel. IV u. 652 S. in 8°. Verlag von Johann Ambrosius Barth, Leipzig 1922.

Lehrbuch der Physik. Von Prof. O. D. Chwolson. 2. verb. Aufl. Bd. 3, 1. Abt. Die Lehre von der Wärme. Herausgegeb. von Prof. Gerhard Schmidt. Mit 166 Abb. VIII u. 450 S. in 8°. Verlag von Friedr. Vieweg & Sohn A. G., Braunschweig 1922.

Statistik der elektrischen Bahnen und Drahtseilbahnen in Sachsen 1921. Aufgestellt von der Direktion der staatlichen Elektrizitätswerke, Dresden 1922.

Technische Schwingungslehre. Ein Handbuch für Ingenieure, Physiker u. Mathematiker bei der Untersuchung der in der Technik angewandten periodischen Vorgänge. Von Dipl.-Ing. Dr. Wilh. Hort. 2. völlig umgearb. Aufl. Mit 432 Textabb. VIII u. 328 S. in 8°. Verlag von Julius Springer, Berlin 1922. Gebunden Grundzahl 20.

Die Organisation der öffentlichen Feuerversicherung in Deutschland. Von Dr. jur. Wessels. 88 S. in 8°. Verlag: Verband öffentlicher Feuerversicherungsanstalten in Deutschland, Berlin 1922.

Das moderne Siemens-Martinstahlwerk, seine Lage, sein Bau und sein Betrieb. Eine Darstellung der metallurgischen u. mechanischen Hilfsmittel des Herdstahlwerks für praktische Hüttenleute, Konstrukteure und Studierende. Von Ing. Hubert Hermanns. Mit 276 Textabb., 1 Tafel u. 27 Zahlentafeln. VIII u. 299 S. in 8°. Verlag von Wilhelm Knapp, Halle a. S. 1922.

Elektrisches Kochen und Heizen. Von Dipl.-Ing. Prof. M. Anthes. Mit 91 Abb. u. 81 S. in 8°. Verlag von Dr. Max Jänecke, Leipzig 1922.

Die physikalisch-technische Untersuchung keramischer Kaoline. Von Prof. Dr. Johannes Stark. Mit 40 Textabb. VI u. 145 S. in 8°. Verlag von Johann Ambrosius Barth, Leipzig 1922.

Translation.

ELEKTROTECHNISCHE ZEITSCHRIFT,
Vol. 43, Dec. 29, 1922, pages 1540-1.
Letters to Editor ETZ.

Acoustic Film.

In an article published on page 1305 et seq. by Dr. Nesper entitled "Acoustic Film" the author relates the prior state of the art and the work done in the field of the sound film. For truth's sake as well as for the sake of honor of the inventors Vogt, Massolle and Dr Engl the content of the said article compels me to ask Dr Nesper for certain explanations in the form of this letter. Dr Nesper mentions in his survey the work and publications of Gaumont, Simon and Ruhmer. He also alludes to the work done by de Forest and Langmuir. He finally deals lengthily with solutions which, according to his claims, have been disclosed by Mr G. Seibt. On the other hand, he fails to mention by a single word the fact that on the day of September 17, 1922, the original exhibition and display of talking films has taken place which are predicated upon the research work done by Vogt, Massolle and Engl. This exhibition was not unknown to Dr Nesper, for he was present at the same. He should have been able from his own impressions to know that here, for the first time, contradistinct to the numerous literature on the sound-film subject which he cites, the talking film has for the first time been carried into practice and has found a technical solution. He also fails to mention the names of the inventors, although he was handed a program on which detailed information is contained covering the nature of the solution of the problem as found by these inventors in brief outline. He passes over the many publications which appeared before his article in nearly all German dailies

and in technical magazines reporting upon the said display. He finally ignores the great number of patents taken out by Vogt, Massolle and Engl up to the time and which have probably not escaped his attention inasmuch as he is a patent expert and from which he certainly could glean quite readily in what the solution of the problem disclosed by those three inventors consists.

All of this is astonishing; but still more striking is the fact that he alleges a number of important ideas originating with the said three inventors to be the intellectual product of Dr Seibt. In order to bring out the facts, I therefore address the following questionnaire to Dr Nesper, to wit:

1. Dr Nesper asserts "The first solution that has been published originates from Dr Seibt." (1918). Has he or anybody else seen or heard the solution alleged to come from Dr Seibt? Where "has it become known?".

2. On what facts is Dr Nesper basing his statement that Seibt has first disclosed the thin-wired glow-lamp for the fixing of the sound frequencies?

3. Where and when did Dr Seibt suggest the Gehrcke glow-discharge lamp for sound-film work?

4. When and where did Dr Seibt suggest or employ the nitrogen-filled capillary glow-discharge tube for the same purpose?

5. When and where did Dr Seibt suggest or use the photo-electric cell for the talking film?

6. When and where did Dr Seibt suggest the electrostatic telephone known in the prior art for the pur-

poses of the talking film? And when and where did Dr Seibt see or exhibit this application or arrangement for the first time?

7. What are the bases upon which Dr Nesper predicates his assertion that "in principle among all producers of sound films, for instance, those based upon Ruhmer, the fundamental arrangements first suggested for technical work by Dr Seibt are carried into practice?"

8. What is the reason underlying the fact that in Dr Nesper's report there is no mention of that he has seen and heard sound-films which originated with the above three inventors?

9. Why is there no mention anywhere in Dr Nesper's report that the first practical solution was started by the said three inventors over 4½ years ago and was publicly exhibited in a large program for the first time?

Berlin-Tempelhof, November 10, 1922. C. R. Forth.

Reply:

Mr Forth demands a reply from me to nine questions. The first seven thereof have been answered already in my article. The individual apparatus suggested by Dr Seibt by the aid of which the solution of the sound-film problem was accomplished essentially by an arrangement effected in the said laboratory, have been originated since 1918, some of them somewhat later, by the firm of Dr. G. Seibt, 9 Hauptstrasse, Berlin-Schoeneberg, and they were there shown to me. It was in this manner that I got acquainted with Seibt's inventions and have since followed them up with interest.

Questions 8 and 9 refer to the accomplishments and the exhibitions by the laboratory of Vogt, Massolle and Dr Engl. The fact claimed by Mr Forth, namely, that a display of talking films took place and was arranged by the said gentlemen at the Alhambra, in Berlin, on September 17, 1922, is correct. Furthermore, that I was present at that display. On the other hand, the program I received does not disclose by any means in what way the sound-film is carried into practice by them. Indeed, what the program contains in a rather feuilletonistic style are mere hints at the means used. But there is no exact relation thereof, and this alone is what concerns the expert. I therefore have intentionally refrained from an attempt to enter, in a technical way, into the work done by the three men in my article published in Etz for lack of any real bases. I merely could have described the aesthetic impression of the show; for such purposes the columns of the Etz have never been available. I do not at all deny that the microphone-telephone, once it has been possible to improve it so that it will do satisfactory work, may represent actual progress. For the time being I may reasonably doubt this, seeing that even at the Alhambra exhibition there was no success in the attempt to insure a good reproducing or amplifying effect. The arrangement "tipped" occasionally in a very doubtful manner with the result that the vocal numbers often caused an impression upon the ear that was painful. Instrumental music, the bark of a dog, while preserving still a character resembling a gramophone, turned out best, relatively speaking. Human speech was mostly entirely unintelligible.

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Of course, all of this means comparatively little, inasmuch as this show was intended to be merely a beginning. It is entirely likely that the three gentlemen in the course of time will attain better results. To be

sure, I doubt whether our moving-picture show houses which were designed only with a view towards optical results, will upon the whole be particularly suited for sound-film displays. However, possibly by the use of the Johnsen-Rahbeck arrangement of the Huth Gesellschaft, for instance, which appears to have attained a far higher degree of perfection, substantially better success may be obtainable in moving-picture halls and rooms.

It seems to be to be a rather unfortunate idea on the part of Mr C R Forth to draw particular attention in his above letter and attack to patent applications. To be sure, the program takes pride in stating that ca 160 German patents and 300 foreign patents were required in order to secure legal protection. However, when examining the patents somewhat more closely it will be found that quantity by far outweighs quality; in fact, what one must be astonished about especially is the large amount of writing work that has here been done. Even with the best of intentions, I fail to see a great invention in this fact that, in 1920, the use of a fly-wheel is made the object of letters patent, in order to uniformize the running of a mechanism. This is merely a little example.

I would have thought it more important instead of attacking the work of others, to so develop the sound-film that it can really be considered for practical use.

Dr Eugen Nesper.

Berlin, December 5, 1922.

DEFENDANTS' EXHIBIT NO. 132.

Nr. 481 Sonntag, den 10. September 1911

Berliner Tageblatt

2. Beiblatt

Der tönende Film.

Vorführung in der Urania.

Von (Redakteur verboten.)

Arthur Fürst.

Vor mehr als zwanzig Jahren wurde in einer der ersten Vorführungen lebender Photographien ein Preisschießen zum Spaß inszeniert. Als die Schützen näher und näher kamen und schließlich mit gezogenen Revolvern auf die ganze Reihenfolge der Bilder feuerten, lief eine Panik in der vordersten Reihe in Chemnitz. Die hatte die Empfindung, daß der Spaß gefährlich sei. Deshalb überlegen. Einige solchen Vorfall schwerer tollischer Erschütterung wird sich manche Besucher der Kinematographentheater in den Anfängen nicht haben vorstellen können, daß man solche Bilder der Schützen, das es selber — als Kunstgenuß kannte, zu sich sprach. Mit beklemmender Gewalt können so plötzlich die tragischen Erscheinungen packen im organischen und im unorganischen Naturreichen vorübergehen. Kaum der Mensch seine Körperlichkeit verleiht nach all seine Erfindungen und Weltanschauungen auslachen, wenn es einem guten Lustspiel gelingt, sein Gebaren komisch wie keine Kunst, als die Schauspielkunst dieser noch mehr bestimmten Bewegungsmöglichkeiten nachzuahmen? Er lernt wieder einmal bescheiden über sein Gehaben zu Gesichtungen denken. Zugleich kann er freilich schmerzen, daß auf dem Zeichnen seiner schaffenden Tätigkeit an einem Epidiaskop ungeschwächt beginnt.

Solche Empfindungen waren jetzt nur in den ersten Augenblicken der Vorführung von lebenden Gemälden möglich. Man merkte auch, daß die Kinematographentheater gegenüber Neuem schnell lernen, daß die Operateure die Kurve in gewissen plötzlicher Filmerschütterung und den Gehen und von allem auch von Kunstbetrachtungen denken. Auch ohne gerade es ist, daß die Bilder dann noch mehr verschwommen als sie, daß nicht mehr gut, besonders, kleinen Kampf, bei ganze Gehe bewegt verschwinden. Kleinen aber kennt man keinen Augenblick im Zweifel sein, hier etwas grundsätzlich Neues, Großartiges und Bildversprechendes gegenüberzustehen, das geeignet ist, der Kultur einen weit- und folgenreichen Fortschritt zu sein. Erinnert man sich, in welch unvollkommener Form die ersten Sprechmaschinen zuerst auftraten, wie wenig man damals noch an sich hören, wie wenigen Abwechslung man bisher Jahrzehnte verwandelten, die schließlich Abwechslung wird eine Kulturtatsache und kaum jetzt sind weiter verwandelt ge- langen, als die erstaunt ist, wenn das Lampe und die Schallplatten Sprechmaschine kennen müssen ist als bekannt.

Die Berliner Operetten und Singer. Die erstaunlich Anerkennung ist bei der gestrigen Vorführungen nicht möglich, da die Klangwirkung leider noch Gegenstand erstaunlich. Die Deutschen Gesellschaft hatte auf ihren Bühnen bereits selbst die Schallen und auf andere in natürlicher Handlung durch Gesang, Sprache und Musik. Sonore Stimmen und Sprechmaschinen, Sprechmaschinen und Sprechmaschinen, Sprechmaschinen und Sprechmaschinen, Sprechmaschin

Translation.

(Berliner Tageblatt, no. 421, September 19, 1922, 1st supplement)

THE SOUNDING FILM.
Presentation in the Alhambra.

(Copyright.)

By Arthur Fürst.

More than twenty years ago, in one of the first presentations of motion pictures, an approaching train was shown. When the locomotive came nearer and nearer and ultimately with huge dimensions filled almost the entire canvas, a woman in the front row fainted. She had the impression that the train was running right into the orchestra seats. Many a visitor of the special presentation in the Alhambra was probably unable to resist a similar feeling of profound emotional agitation when for the first time the phantom which he had theretofore known only as silently movable spoke to him. With a reverberating crash the firmly fixed wall of separation between the organic and the inorganic halves of Nature seemed to topple over. Can man really still conceive of his corporeal structure as a paramount achievement of the creator of the world if a flat little piece of celluloid can succeed in copying his actions as well as his speech, i. e. the totality of his externalized possibilities of activity? He learns once more to form a modest opinion as to his position in the universe. At the same time he can of course perceive that a new story is commencing to grow upward on the pantheon of his creative activity.

Such impressions, however, were possible only during the first moments of the presentation last Sunday. It was perceived that the cinematographically shown figures could actually speak, and that the apparatus presented the words in the most exact temporal

correspondence with the gestures and particularly also with the mouth movements. Soon, however, it became evident that the style of this speech is nevertheless still far from perfect, that much still sounds distorted, strange, and metallic, and that whole sentences remain altogether incomprehensible. In spite of this, however, it was impossible to doubt for a moment that one was here confronting something fundamentally new, magnificent, and very promising, which is suitable to be the beginning of an extensive and radical development. If we recall in what an imperfect form the pure motion pictures at first appeared, it will not prove difficult to predict a happy future for sounding motion-picture presentation. The acoustic department will in all probability even progress much more rapidly than the optical was able to do, because the rate of technical advance is considerably more rapid today than at that time.

We heard speakers and singers. Real artistic enjoyment was impossible in the case of the vocal presentations, since the timbre of each voice seemed altered. The speaking persons fully evoked, for short periods of time, the illusion as though they were real actors. This feeling was, however, rapidly killed off again and again by the imperfection of the operating machine. The latter was able to deal far better with the tones of the musical instruments. A violoncello concert was able to produce a very satisfactory effect, and the tones of the flute and the clarinet likewise came out splendidly. The reproduction of a violin solo proved very unsuccessful. On the other hand the barking of a large dog and the squealing of a pig met with unanimous approval. In these Nature was captured perfectly.

From the point of view of physics, the state of affairs is this, that the apparatus, which has been created in years of development by Hans Vogt, Dr.

Jo Engl, and Joseph Masolle, is even at the present time capable of reproducing all low tones very well. Here, where the number of sound-vibrations per second is comparatively small, the reproducing instruments follow completely, even now. On the other hand, they still fail easily with respect to vibrations of higher frequency and those with numerous overtones. Among these there belong in particular many constituents of human speech: the sibilants, with their so extremely complicated vibration curves, have a lisping sound, just as in the telephone and the gramophone.

If one regards the presentation only as a brief halt on the still lengthy road to the goal, there is reason enough to congratulate the designers on their work. They have had to overcome endless difficulties in order to reach the result which is even now amazing and impressive. The recording is effected by means of entirely new microphones, which no longer have any movable material parts. For the amplification, both on the recording side and on the reproducing side, the high-vacuum cathode tubes had to be elaborated in a special form. In order to carry the tones through the entire hall in the reproduction, loud speakers of a perfected type had to be developed. Many of the numerous treacherous points which just these pieces of apparatus have are tremendous. But here there is the soundplate, i. e. a corporeal object which has to execute movements. On the other hand, precisely the thing which seems the most difficult to a layman, namely the synchronism, the temporal correspondence of the optical and the acoustic event, is attained to the very last degree. The tone and the picture are photographically recorded on the same celluloid strip and can therefore never be mutually displaced.

The recording of the tones takes place in that a plurality of microphones converts the sound-vibrations into electrical oscillations. These electrical fluctua-

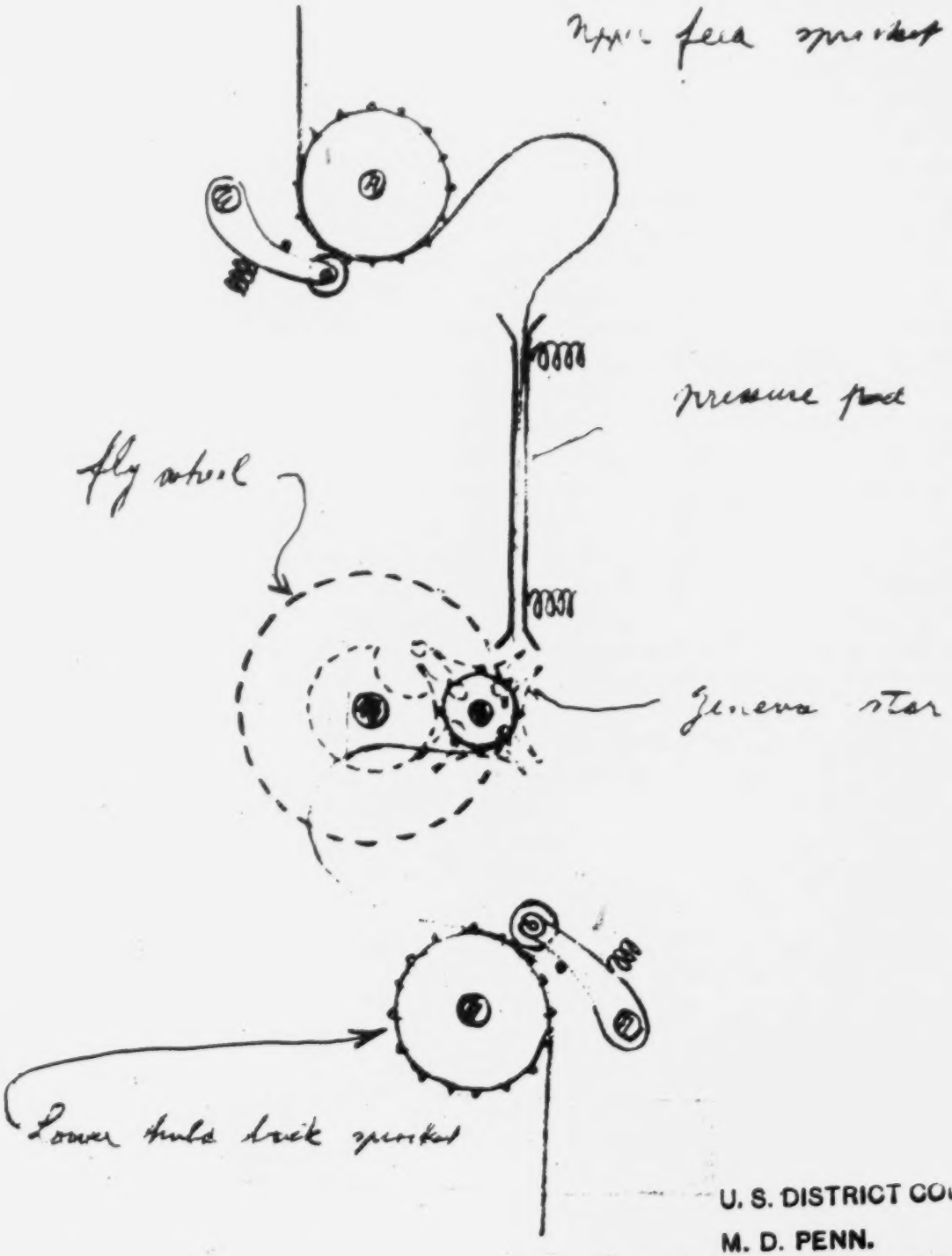
tions are amplified by means of amplifier tubes and control the light of a lamp which falls through a very narrow slit upon a division of the film strip which is traveling forward. Fluctuations of light which correspond to the original fluctuations of sound are now photographically retained on it; the tone strip of the film receives blackenings of a varying kind. In the reproduction a quietly burning source of light is placed in front of the traveling film. It shines through it upon a cell sensitive to light, which is accordingly illuminated in conformity with the film blackenings. It converts the light-vibrations into electrical oscillations. The latter act upon the sound-plate of the loud-speaking telephones, whereby the last reconversion, namely from electrical oscillations to sound-vibrations, is performed. The mastering of each part of this fourfold conversion of energy rendered necessary a host of new inventions. Instruments of the gramophone type are no longer used because of their excessive imperfection.

From the reception of the tone presentations, which in spite of all defects aroused enthusiasm, the group of three men will surely derive encouragement for vigorous prosecution of their work. Other persons, too, are endeavoring to find the perfect solution of the same problem, as, for instance, in Berlin a group which is under the direction of DeForest and Dr. Loewe and which has likewise already attained very good results. It is accordingly necessary henceforth to reckon with the fact that the talking film exists. The film industry and the presentations in the motion-picture theaters are facing a decisive change. Presumably the silent film will never disappear entirely. In addition to many other things, there is still available to it the presentation of natural processes which take place silently, of occurrences which from their whole style wish to act and are able to act only upon

the eye, of humorous caricatures, and of dramatic episodes which require no words. But the drama itself will get back to its natural manner of presentation. When people experience something which excites them, they speak. The silent motion-picture of the present day tries in vain to get over this by illusion, with the employment of colossal external means. Even yesterday, however, at the naturally still very imperfect presentation of a one-act play, it was clearly perceptible how much more profound an impression the talking animated picture is able to make by means of simple theatrical presentation than the most expensive crowd film and elaborate film. When the technical means are at hand in finished shape, the demand for the product that is current today will disappear of itself. Anyone who has the choice does not go to an institution for the deaf and dumb when he wishes to be entertained, but seeks the company of persons possessed of all their faculties. For the present the famous crowds of supers and the beautiful girls who know how to make such round, touching eyes will continue to be set in motion. But in the not too distant future only the genuine artist with a command of speech will hold sway in the motion-picture studios also.

DEFENDANTS' EXHIBIT NO. 133.

Schematic View of Eyeman II Projector '33



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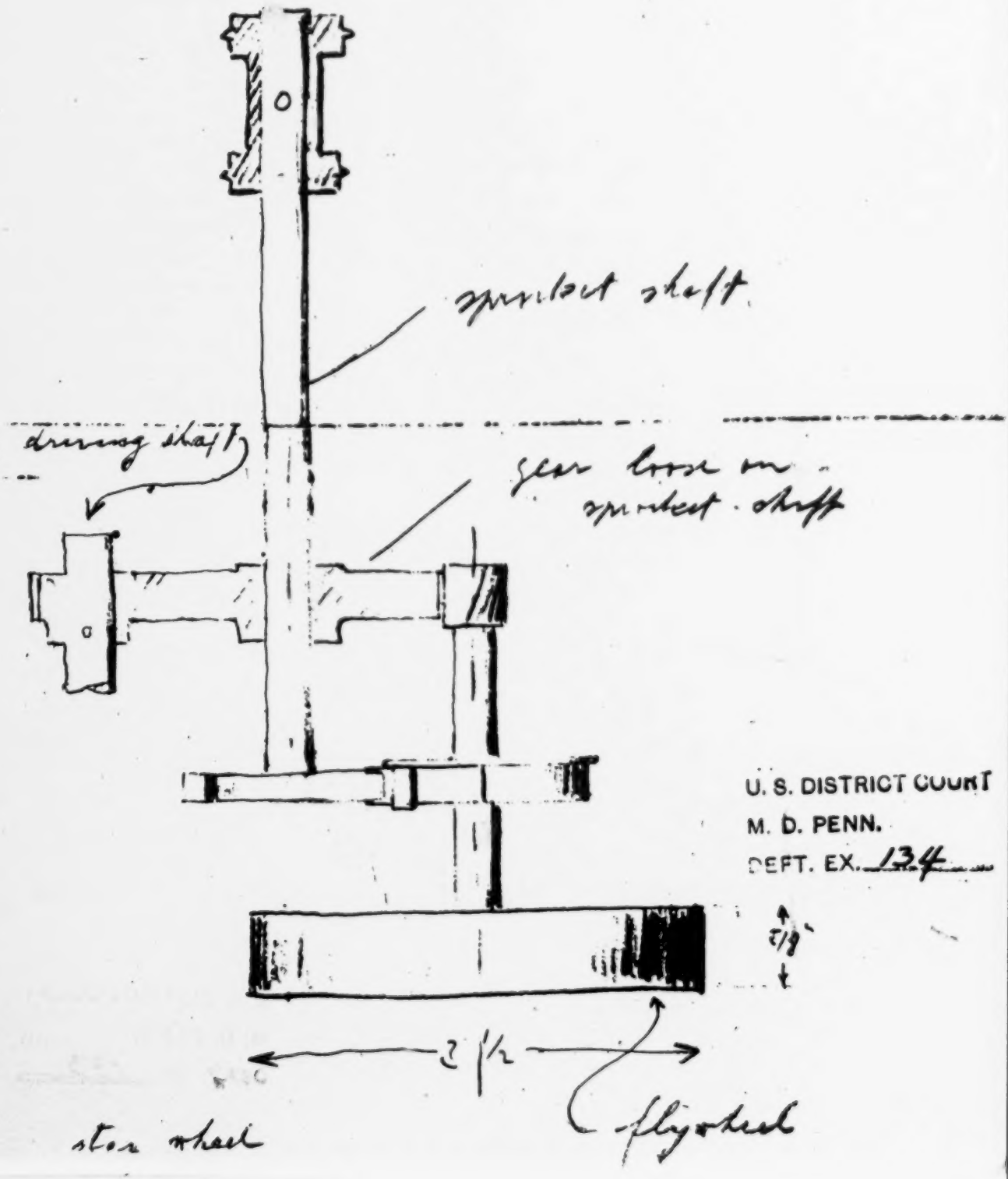
DEFENDANTS' EXHIBIT NO. 134.

Intermittent of Einemann II 134



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DEFENDANTS' EXHIBIT NO. 135.

Patents of Vogt, Massolle and Engl, Listed at Record Pages 826-827.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 136.

Binder of Patents Cited During Prosecution in German Patent Office of German Patents Nos. 387,058, 389,317, 389,318, 389,319; and in Nullity Proceedings In Re Same Four German Patents; and Patents Cited in the Nullity Decisions With Respect to German Patent No. 417,916, With Translations, Listed at Record, Pages 828-835.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 137.

IN THE
UNITED STATES COURT OF CUSTOMS AND PATENT APPEALS

Patent Appeal Docket No. 2,749.

INTERFERENCE No. 53,103.

LEE DEFOREST

vs.

VOGT, MASSOLLE and ENGL.

BRIEF FOR VOGT, MASSOLLE and ENGL.

KENNETH S. NEAL,
Attorney for Vogt, Massolle and Engl.

S. MORTIMER WARD, JR.,
of Counsel.

FILED
United States Court
of Customs & Patent Appeals
APR 18 1931
Arthur S. Shelton, Clerk.

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should be taken as diligence in the perfecting of the invention at issue—an entirely different invention—it may be well to discuss this point first before taking up the other testimony on diligence.

It will be understood that the recording of sound on film was a well understood and known accomplishment at the date of DeForest's conception of the invention at issue. It is disclosed in numerous patents and had actually been accomplished not only by others but by DeForest. It may be well to point out here that in the above referred to companion interference #51947 between DeForest and these same inventors, the invention there at issue was this very idea of recording sound on film by a particular lamp—a glow lamp. DeForest won that interference before the Examiner on this very contention of his diligence in working on the problem of sound recording. It availed him there because sound recording by glow tube was the invention there at issue; but it cannot avail him here. Such work was work in completing the invention of that issue; but in this case he has totally neglected the invention here at issue in order to continue on that other work to find out which of several different light sources "was the most practical." That was his privilege. But he cannot now complain because he totally neglected the invention here at issue to continue to research throughout the ramifications of the problems relative to recording sound.

His notebook shows that at the time when he should have been diligent with the invention here at issue—if he had conceived it—he, instead, was exploring every conceivable arrangement, combination and system of instrumentalities for recording sound, with a view, no doubt, of protecting all valuable ideas

along that line. He was trying out all of these various systems, methods and devices not only with one particular source of light, but as he testifies and as his notebook shows, he was trying it out with each of the three different sources of

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long before he left New York—referring to his going to Berlin in July, 1921, as here and also there testified to. From his previous testimony, above quoted, it is shown that he first worked out results with the incandescent filament type of lamp even before this; and his notebooks here record that he then took satisfactory sound film with the flame light, and thereafter with the glow tube. He therefore, like others, according to his records, was able to make "satisfactory talking films" prior to the entry of Vogt, et al., into the field of this present issue. They may or may not have been as perfect as DeForest ultimately hoped to get them, but it is shown by testimony in this case, and by his notebooks, that he had successfully recorded sound, **and as early as October, 1920, according to his notes, had gotten "excellent" records.** He could readily have done so in conjunction with taking motion pictures to reduce the present invention to practice, if he had seen fit to do so—if he had not neglected and abandoned it for another solution of the problem, which apparently he preferred, as will later be shown.

His notebooks, in evidence, from a period even prior to his conception, until the filing of his application in this case, both prior to and after the entry of Vogt, et al., into the field, contain numerous entries by him to the effect that utilizing a "speaking flame" lamp he got sound films which were "very good"—"Fine, excellent," "quite good," and similar remarks showing that he could record sound, so as to reduce this invention to practice if he had had a mind to do

so. Such entries in his notebooks will be found, for example, at the following places, and there are many others: October 16th and 20th, "Good"; October 20th and 21st, 1920. "Very good"; November 9th, referring to experiments 7 and 8, "Very good, fine, excellent! Best yet," and other laudatory statements continuing on, and again on January 16th, 1921, with reference to experiments 2 and 3, "Excellent,"

DEFENDANTS' EXHIBIT NO. 138.

Transcript of Trial Minutes and Briefs for Plaintiffs, in American Tri-Ergon Corporation, et al., v. Robertson, Equity No. 47,904, in Supreme Court of District of Columbia.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 139.

Translation.

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I. Sodium Amalgam for Photo-electric Experiments.

By: J. Elster and H. Geitel.

While the light rich in ultra violet rays of the electric spark or arc causes the escape of negative electricity from the surface of the most varied substances, the number of substances which in like manner react on light sources of a smaller content in short wave rays (for instance, sunlight and daylight) is far more restricted. As we have found a short time ago (J. Elster and H. Geitel, Wied. Ann 38, page 497, 1889), pure surfaces of certain electro-positive metals such as zinc, aluminum, magnesium, are suitable in this connection. The first one of the said metals retains its property even after the addition of mercury—a remarkable analogy with its behavior in the galvanic chain; the two other metals are not at all capable to form air resisting amalgams. The idea that perhaps their electro-positive character could be connected with the photo-electric behavior induced us to use metals of still more decided positive properties namely sodium and potassium. Also here for experiments in the open air only amalgams can be used and even these can only be used provided their surface is in a state of continual renewal. We obtained this in the manner that we caused rays containing a small amount of liquid amalgam of these metals to emerge from small glass receptacles and

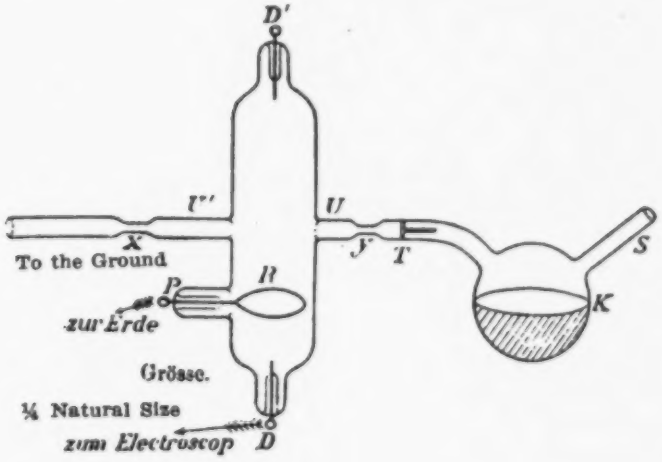
that we let the light act only on the upper part of the rays.

The effect, in spite of the very small effective surface, was so great that one could expect that, upon the enlargement of the surface, one could obtain a still higher sensitivity than shown by plates of amalgamated zinc. An enlargement of the cross section of the amalgam rays would have led to great difficulties and we therefore made use of a completely changed process. In accordance with the experiments of Righi (A. Righi, Atti del R. Instituto ven. di Scienze, 7, (6) page 51, 1889, Beibl. 13, page 976, 1889), the photo-electric energizing by zinc arc light increases upon continued rarefication of the air. We found, in agreement herewith, that also the discharge velocity of negatively electrified surfaces upon the reduction of the pressure to about 1 mm., increases to 6 to 7 times that observed at normal pressure. The pertinent experiments were carried out with light from electric sparks. We now assumed that sodium amalgam which is sensitive to ordinary daylight, after it had once been placed, with a clean surface, in an evacuated tube, would retain its reaction capacity for quite some time; at the same time in connection with this process it was possible to expose to the light, effective surfaces of several square centimeters. The success obtained confirmed our expectations throughout. The production (manufacture) of evacuated tubes with electrode surfaces of sodium amalgam by means of a Töpler-Hagen Air Pump, does not offer any difficulties.

A cylindrical glass receptacle (see Fig.) carries at both ends small platinum wires D D′ provided with loops sealed into the glass, which are covered on the inside up to near their outermost end with glass. Furthermore, a ring R of platinum wire is introduced; it is in metallic connection with the platinum wire P sealed in the laterally arranged tube (neck). On the

opposite side a tube U carries the bulb K, closely in front of which there is inserted a small funnel T directed toward the bulb (as in the case of a Holtz valve tube). An open glass tube S makes it possible to fill the bulb K with amalgam, while another glass tube U′ serves for the connection of the apparatus with the pump.

It must also be stated here that for the making of connections—outside of the direct sealing of the glass—we only make use of mercury sealings and do not use any grease (fat) at the ground parts. A glass cock which is made to operate smoothly by means of syrup-like phosphoric acid, and sealed with mercury, makes it possible to seal, in an air-tight manner, the pump including its dry bulb (ball), from the receptacles molten (sealed) to a ground part; the latter can then be removed and replaced avoiding in this way that, after the opening of the cock, more air enters into the pump than was contained in the receptacles and in the connecting tubes.



After the said receptacle with the cock closed is connected to the pump, sodium-containing mercury, which is to be as dry as possible, is let to flow down, by means of a fine funnel tube, to the bottom of the bulb K. (The correct content of sodium is obtained in the manner that there is introduced into pure mercury a sufficient quantity of solid sodium amalgam so that at ambient temperature a part of the latter remains undissolved.) After introduction of the amalgam, the tube S is drawn as quickly as possible into a sealed point, the cock of the pump is opened and, while heating the amalgam up to an active evaporation of the mercury, the receptacle is evacuated. In this condition, it is left for several days, connected with the pump, in order to effect as complete a drying out as possible, and also in order to effect the absorption of the still remaining oxygen by the sodium amalgam. The latter is covered with a gray oxide-containing skin. As soon as—even in case of longer standing—the pump no longer indicates any pressure increase, the apparatus evacuated to the utmost obtainable limit, is sealed at the narrow place x, and after sufficient cooling of the place of sealing, the liquid metal by the inclining of same may pass from the bulb into the receptacle. Any impurity remains in the bulb; the surface is entirely metallic. One can now either remove the bulb K with the funnel, by melting off (sealing) at the place y, or it is left on the apparatus, and in this way it is possible, in the event that the surface should not remain absolutely clean, to return the amalgam through the funnel T entirely into the bulb K and renew the filtration. One can note that it would be inadvisable to direct the point of the funnel toward the receptacle; it would be impossible to return into the bulb the last residues of the amalgam, on which the possible impurities accumulate. The immediate vicinity of the wires D D′, and also P,

is coated with a little shellac varnish, so that the outside of the receptacle remains insulating.

For the making of photo-electric experiments, the apparatus is placed in such a position that D and D′ fall into one vertical line. R remains continuously grounded; depending on whether D or D′ is below, one is able to place the earth (ground) connection at a smaller or greater distance from the amalgam surface. By means of a wire hooked in at D or D′, respectively, the latter is connected conductively with a gold-leaf or aluminum-leaf electroscope.

If, in connection with this arrangement, the apparatus is exposed to bright daylight or sunlight, one can easily note that it does not take up at all static negative charges. An electric ebonite rod brought near to it, perhaps causes a twitching of the leaf; the divergence disappears, however, almost instantaneously. Upon removal of the rod, the leaves jump apart with positive electricity as if the electroscope had previously been touched conductively. This positive charge is also retained in intensive sunlight.—The experiment is more suitably made in the following manner:

The apparatus is set up near a window which can be closed by a shutter; D communicates, aside from communicating with the electroscope, also with the negative pole of a Zamboni's dry pile consisting of many couples (of about 200 volt free tension), the positive pole of which is connected with R and thereby grounded. When the shutter is closed, the leaves diverge under the angle corresponding to the voltage of the pile; upon opening of the shutter, they go gradually more together, until, upon sufficient light intensity, the divergence disappears completely. It is sufficient to screen off, by means of a screen, a part of the light striking the amalgam surface, in order to again produce a clear divergence.

The use of potassium amalgam, instead of the corresponding sodium compound, does not appear to offer any advantages.

As appears from the description, there is not arranged any device on the apparatus by which it is made possible for rays of the shortest wave length to enter into same. Quartz windows and the like are unnecessary. The light let pass by the glass appears to be sufficient. In accordance with this, the apparatus is also sensitive to rays of slight refrangibility, of the kind, for instance, emitted by an oil lamp or by glowing sodium vapor (in a Bunsen burner). It is true that here the effect is weaker than in daylight; however, it can still be measured in an absolutely clear manner.

It is advisable to keep the apparatus in the dark; in case of continuous illumination by sunlight, the upper limit of the contact surface of glass and amalgam appears to change; the metal starts here to adhere to the walls, while previously, in the same way as pure mercury, it did not show any inclination to adhere. We intend to again refer to this phenomenon and also to other experiments to be made with the apparatus.

We assume that the surfaces—prepared in accordance with the Warburg method /Warburg, Wied. Ann. 40, Page 1. 1890/—in vacuum tubes of pure sodium, will also show a photo-electric sensitivity like that of the amalgam.

DEFENDANTS' EXHIBIT NO. 140.

PATENT OFFICE
178-C
CLASSIFICATION

N° 3701 A.D. 1908

140

U. S. DISTRICT COURT
M. D. PENN.
DEFT. EX. 140

(Under International Convention.)

Date claimed for Patent under Patents and Designs Act, 1907, being date of first Foreign Application (in Germany), 25th Feb., 1907

Date of Application (in the United Kingdom), 18th Feb., 1908

At the expiration of twelve months from the date of the first Foreign Application, the provision of Section 91 (3) (a) of the Patents and Designs Act, 1907, as to inspection of Specification, became operative

Accepted, 4th June, 1908

COMPLETE SPECIFICATION.

"An Improvement in the Method of Transmitting Graphic Signs, Photographs and the like by Means of Electric Current."

We, "Polyphos" Elektrizitäts-Gesellschaft m.b.H., of 16 Schillerstrasse, Munich, in the German Empire, Manufacturers, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The transmission of graphic signs, pictures, and the like by means of electric currents has been effected by utilizing the fact that the electrical conductivity of selenium varies with the intensity of the light falling upon that metal. The change of conductivity, in the case of selenium is, however, not simultaneous with the change in the intensity of the light, that is to say, the increase or decrease of conductivity does not take place at once when the intensity of the light-rays changes. The conductivity does not, for example, immediately revert to its original value when the intensity of the light reverts to its original value. Owing to the lag which occurs the transmission cannot be very rapidly performed when selenium and light are the agents by which the current-strength is caused to vary.

This disadvantage is obviated by the present invention, which enables the transmission of graphic signs, pictures and the like to take place much more rapidly.

One of the methods which have heretofore been suggested for producing alterations in the resistance between separated electrodes consists in ionising the gaseous medium between the electrodes, and the application of light-rays is one of the means which have been proposed for effecting the ionisation of the medium. Both in wireless telegraphy and in ordinary line-telegraphy use has been made of ionised gaseous media, that is to say, of gaseous media in a state of molecular activity associated with reduced electrical resistance.

The present invention also involves the use of a gaseous medium and of light-rays, the gaseous medium being, as it were, substituted for the selenium referred to in the opening paragraph of this specification. The method by which, according to the invention, the electrical resistance of the gaseous medium is caused to vary consists in causing the varying light to fall upon a substance

which is in contact with the gas and has the property of emitting electrons at a rate varying with the intensity of the light. The varying emission of electrons into the gaseous medium is accompanied by the desired variation of the resistance of the medium.

Substances suitable for the purpose indicated are, for example, the alkaline metals, potassium, sodium and rubidium, which emit electrons into a gas, for example rarefied hydrogen, when light-rays fall thereon. The gaseous atmosphere is thus rendered more conductive, and the current-strength in an electric circuit of which the gas forms part, is increased. This increase of current is proportional to the intensity of the illumination and the change of conductivity is simultaneous with the change in the strength of the light. The important advantage is thus obtained that the succession of exposures to light of different intensities can be considerably more rapid than if a selenium-cell is used, and a considerably quicker transmission is obtained.

One way of carrying out the said invention consists, for example, in placing two electrodes in a glass tube containing rarefied hydrogen, one of these electrodes, connected to the positive pole of a current-generator, being, for example, of platinum, and the other, connected to the negative pole, consisting of a substance which emits electrons when illuminated, for example sodium. Apparatus of known construction for the transmission and reproduction of pictures, graphic signs and the like is arranged in the electric circuit and operated by fluctuations of current which are produced by exposing the sodium to light of varying intensity.

The current fluctuations due to changes in the conductivity of the gas may, of course, be used to operate a relay instead of acting directly on the transmitting apparatus.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

In the electrical transmission of graphic signs, photographs and the like by means of variations of current-strength corresponding to variations of light, the method of producing said variations of current-strength by causing the light of varying intensity to act on a substance which emits electrons at a rate varying with said intensity and by utilizing the varying emission of electrons to vary the electrical conductivity of a gas forming part of the circuit.

Dated this 18th day of February 1908.

HERBERT HADDAN & Co.,
Agents for Applicants,
31 & 32 Bedford Street, Strand, W.C. London.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1908.

DEFENDANTS' EXHIBITS NOS. 141-A, 141-B.

Application as Originally Filed of DeForest Patent No. 1,466,701, and Copy of Patent as Issued September 4, 1923.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 142.

GENERAL ELECTRIC COMPANY
SCHENECTADY, NEW YORK

August 20, 1925.

ALBERT G. DAVIS
Vice President

PATENT DEPARTMENT
RECEIVED
Aug. 21 1925
Answered .....

Mr. Ira J. Adams,
Radio Corporation of America,
233 Broadway,
New York City,

My dear Mr. Adams:

Mr. S. A. Schrader of 200 Fifth Avenue, New York City, called at Mr. Burchard's office the other day, stating that he represented a German device which is somewhat along the line of our pallophotophone, which is known as the Triergon, and wanted to know if we were interested in acquiring it. I spoke to Mr. Sarnoff about the matter and he suggested that you should ask the man to come and see you because it is likely that the Radio Corporation will take over our pallophotophone rights.

Therefore, I would suggest that you have this man come in and talk with you, and that you ask Mr. Dunham to give you whatever information we have about the Triergon device.

Yours very truly,

ALBERT G. DAVIS.

DEFENDANTS' EXHIBITS NOS. 143-A, 143-B.

Application as Originally Filed of Nicholson Patent No. 1,470,696, October 16, 1923, and Copy of Patent as Issued.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 144.

File History of Bell & Tainter Patent No. 341,213, of May 4, 1886.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 145.

File History of the Bell & Tainter Patent No. 341,214, of May 4, 1886.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 146-A.

Extract
from a Decision of the German Supreme Court
of December 17, 1932.

The main patent has not been published prior to the patent of addition; therefore, it does not belong to the state of the art. The patent of addition must be maintained if that which it discloses beyond the subject matter of the invention of the main patent, proves of inventive character as compared with the state of the art to be considered.

DEFENDANTS' EXHIBIT NO. 146-B.

Extract
from a decision of the German Supreme Court of
January 26, 1897.

Although the granting of a patent of addition is based on the existence of an invention ....., the decision of the Imperial Patent Office in harmony with this principle states that the process of the attacked patent only then would be entitled to patent protection, if with the production of the esters mentioned in the patent of addition as compared with those described in the main patent, an essentially new technical effect could have been shown.

DEFENDANTS' EXHIBIT NO. 147.

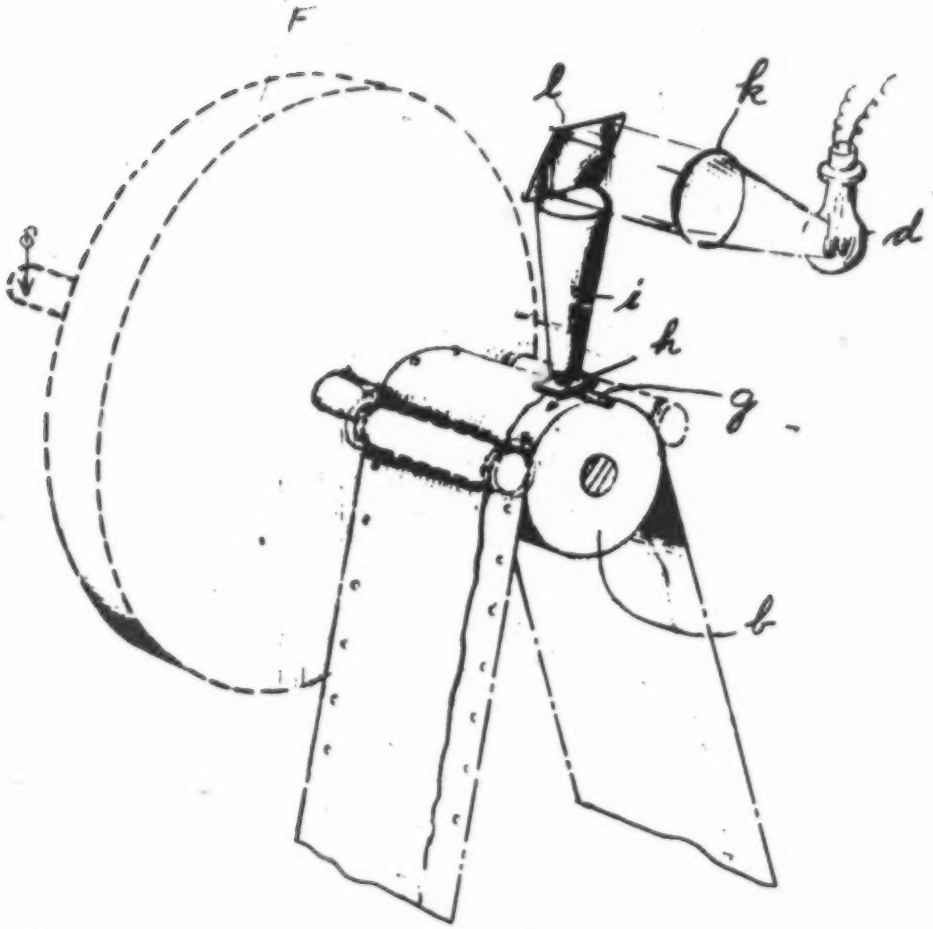
File History of the Underhill Patent No. 995,390, Granted June 13, 1911.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 148.

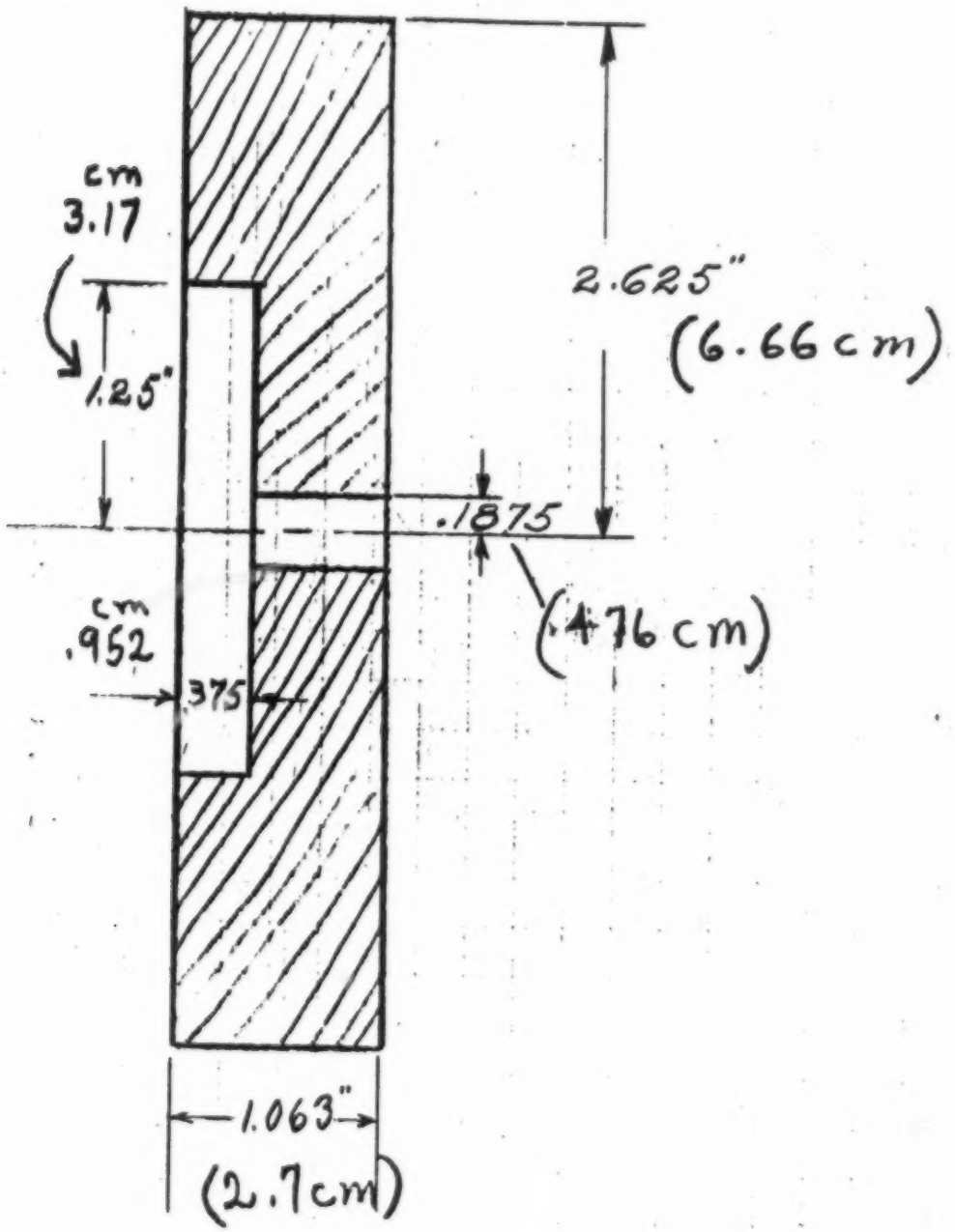
D-148 Sketch of (copy left from Zeidler) Deft Ex 148

PEDERSEN
BR.PAT.-115,942
(1918)



DEFENDANTS' EXHIBIT NO. 149.

Name	Weight gm.	Moment of Inertia gm. cm.^{2}	R. P. M.	Kinetic Energy ergs.
P S —1	2372 (sound)	56200	360	39,900,000
P S—16	1220 (sound)	17950	348.6	11,950,000
Simplex Projector	355	5100	1440	58,200,000
Powers Projector	605	10000	1440	114,000,000
Ernemann II Projector	631	6682	1440	76,200,000



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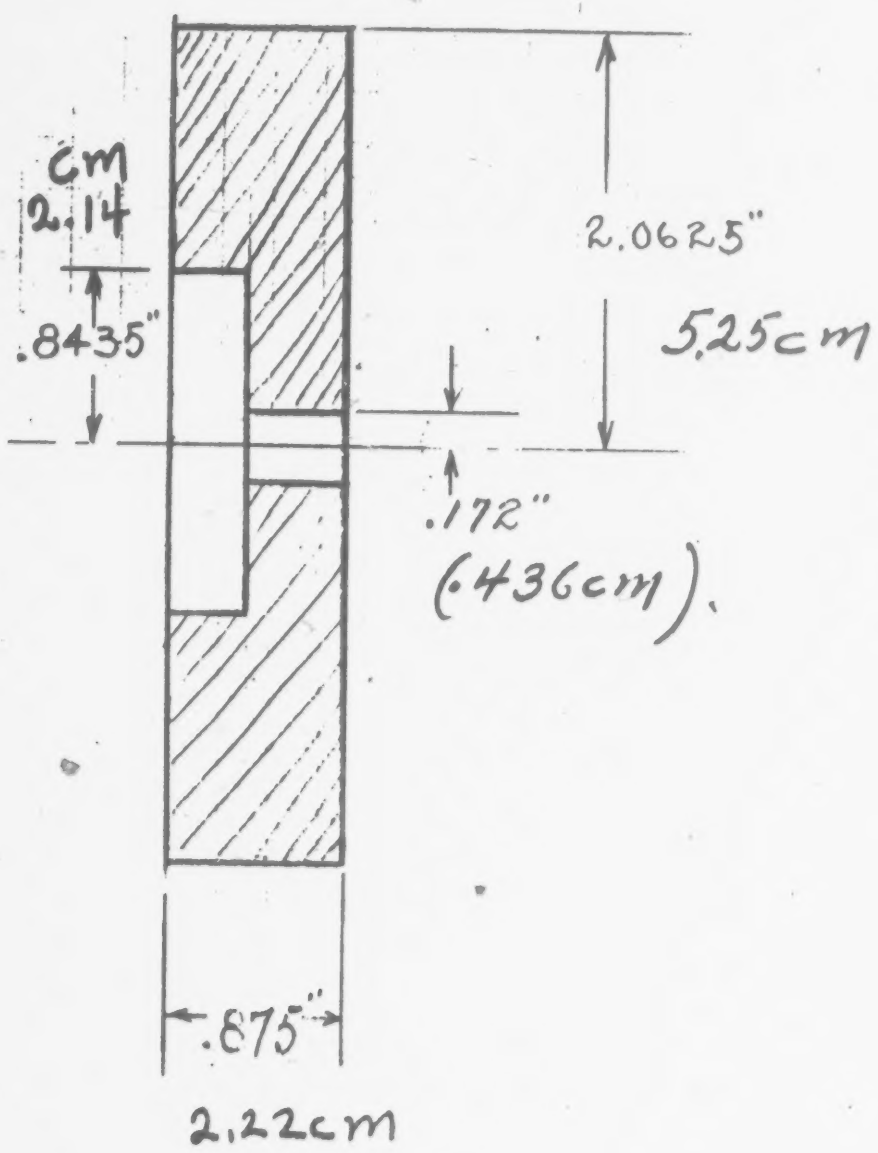
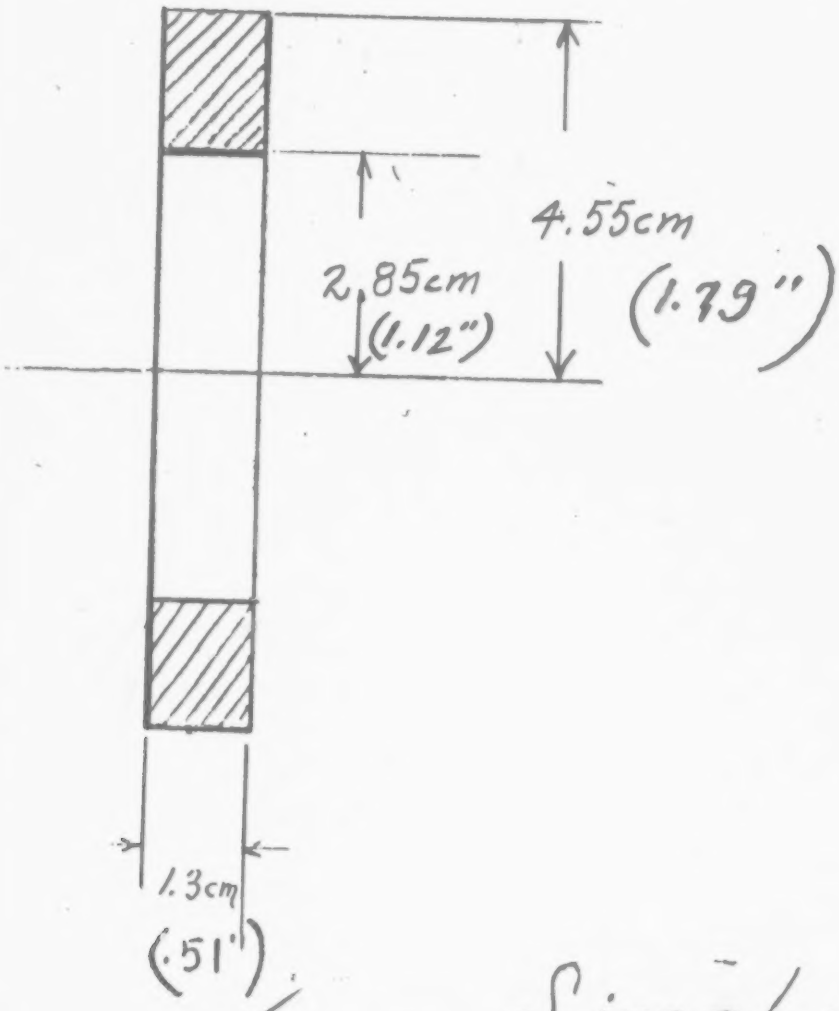
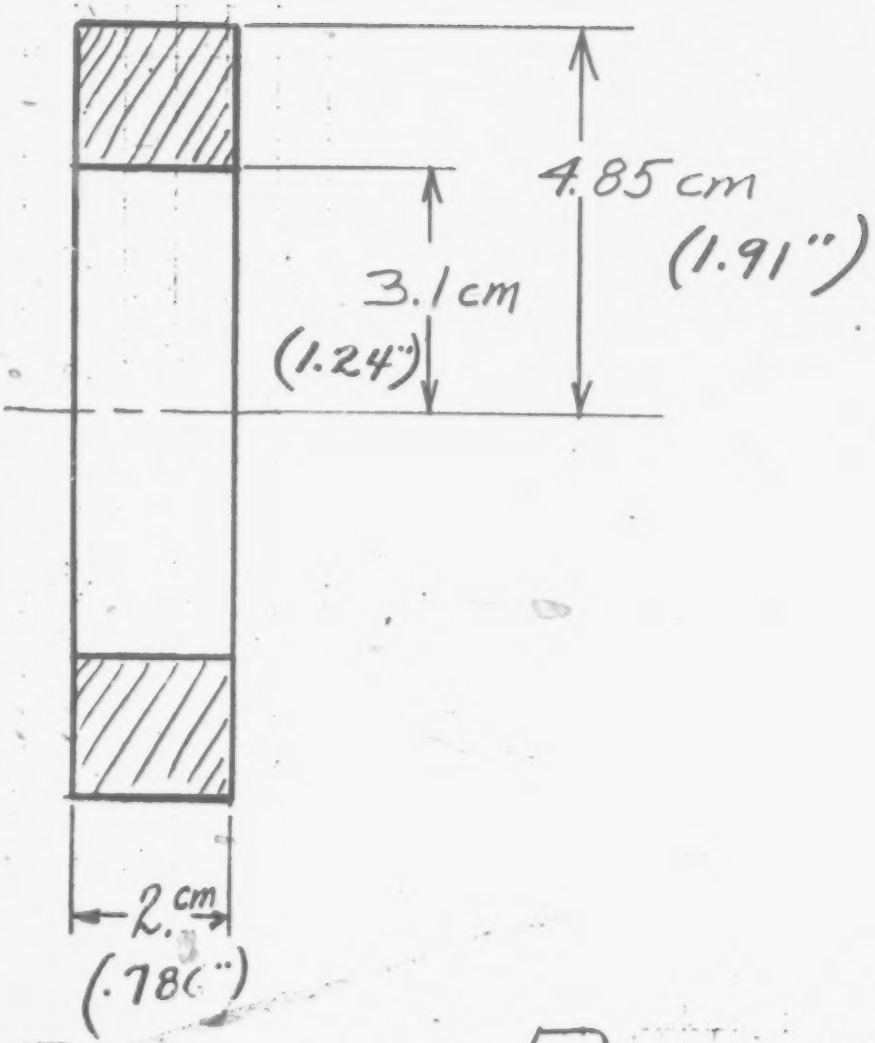


PS-16

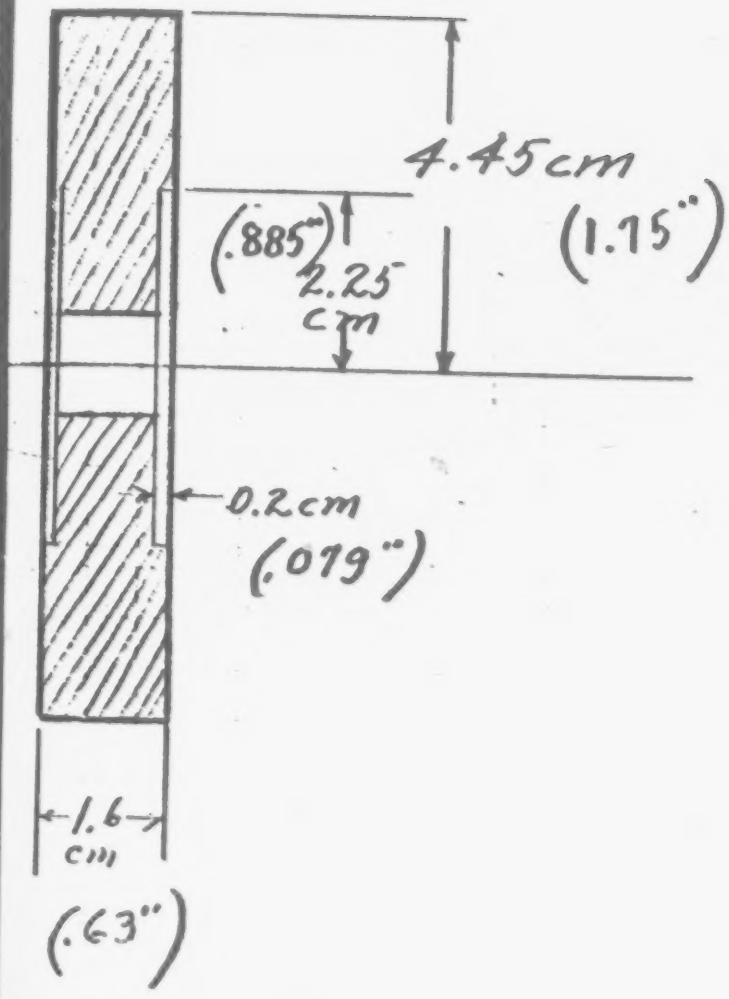


Simplex Projector

1722



Powers Projector



Erkemann II Projector

DEFENDANTS' EXHIBIT NO. 150.

LIST OF ENGL, VOGT AND MASSOLLE PATENTS.

German Patents.

Filing Date	Patentees	Number and Title
June 18, 1915	Seibt, Vogt	300,852. Radiation structures for wireless transmission.
Sept. 12, 1918	Seibt, Fabrik Elecktrischer Apparate, Vogt	313,759. Socket for amplifier tube.
Mar. 4, 1919	Vogt, Engl, Massolle	417,967. Method for the photographic recording of optical and acoustic manifestations and their reproduction by means of a constant light source.
Mar. 4, 1919	Massolle Vogt, Engl	353,644. Differential coupling for controlling the amplitude of high frequency, undamped vibrations in the rhythm of acoustic vibrations.
Mar. 4, 1919	Vogt, Engl, Massolle	358,115. Electric glow lamp for the photographic recording of sound waves.
Mar. 4, 1919	Engl, Vogt, Massolle	365,900. Photoelectric cell developed as a black body.
Mar. 4, 1919	Engl, Vogt, Massolle	365,901. Photoelectric cell with increased photoelectric efficiency.
Apr. 4, 1919	Engl, Vogt, Massolle	317,895. Arrangement for the production of electric vibrations.
Apr. 6, 1919	Massolle, Engl, Vogt	350,705. Device for the recording of sound waves.
Apr. 6, 1919	Engl, Vogt, Massolle	350,706. Device for the optical recording of sound waves by means of several diaphragms.
Apr. 8, 1919	Massolle, Engl, Vogt	350,506. Device for the control of the amplitude of high frequency oscillations in rhythm with low frequency oscillations.
Apr. 9, 1919	Massolle, Engl, Vogt	350,437. Capacitive telephone.

Defendants' Exhibit No. 150

Filing Date	Patentees	Number and Title
Apr. 17, 1919	Massolle, Engl, Vogt	350,999. Connection for the amplification of electric currents or voltages by means of discharge vessels.
May 18, 1919	Vogt, Massolle, Engl	350,499. Electro-static telephone.
May 18, 1919	Vogt, Massolle, Engl	350,707. Device for the synchronous reproduction of optico-acoustic events, especially for the purposes of cinematography.
June 3, 1919	Engl, Vogt, Massolle	368,367. Device for producing photophonograms, especially for acoustic moving pictures.
June 4, 1919	Engl, Massolle, Vogt	368,368. Device for production of photophonograms, especially for the purposes of acoustic cinematography. (Addition to Patent 368,367.)
June 4, 1919	Vogt, Engl, Massolle	368,369. Device for producing photophonograms, especially for acoustic moving pictures. (Addition to Patent 368,367.)
July 3, 1919	Massolle, Vogt, Engl	376,320. Cinematograph provided with a feed member serving as a point for projection.
July 26, 1919	Massolle, Vogt, Engl	387,059. Arrangement for distortion-free amplification of sounds and tones for the purposes of acoustic cinematography.
Aug. 3, 1919	Vogt, Engl, Massolle	350,500. Process for the control of electric currents and sound forces.
Aug. 9, 1919	Massolle, Engl, Vogt	344,886. Circuit for amplification of electric currents and potentials.
Aug. 26, 1919	Engl, Vogt, Massolle	350,708. Device for the recording and reproduction of acoustic processes for the purposes of photo-cinematography.
Oct. 9, 1919	Engl, Vogt, Massolle	350,507. Arrangement for photo-electric alkali-metal cells.
Oct. 9, 1919	Engl, Massolle, Vogt	350,508. Circuit for photo-electric alkaline-earth-metal cells in connection with which a high ohmic resistance is inserted in series with the cell and the voltage source.

Filing Date	Patentees	Number and Title
Oct. 28, 1919	Vogt, Massolle, Engl	350,584. Electrode system for vacuum tubes.
Dec. 3, 1919	Massolle, Engl, Vogt	350,585. Arrangement for amplifying electric current and voltages.
Dec. 3, 1919	Massolle, Vogt, Engl	350,586. Electron tubes with at least two grids.
Dec. 3, 1919	Massolle, Vogt, Engl	369,074. Multi-tube amplifier with all steps on the same cathode.
Dec. 3, 1919	Massolle, Vogt, Engl	391,982. Bridge connection for the amplification of electric currents or voltages.
Dec. 23, 1919	Engl, Vogt, Massolle	350,709. Device for the reproduction of photographically recorded sounds by electro-optical means.
Jan. 18, 1920	Vogt, Engl, Massolle	374,281. Photophonogram carrier for the purpose of talking films.
Jan. 30, 1920	Vogt, Engl, Massolle	350,501. Arrangement for sound reception by utilizing electric current vibrations.
Feb. 26, 1920	Vogt, Engl, Massolle	351,955. Incandescent cathode for microphone.
Mar. 27, 1920	Massolle, Engl, Vogt	392,897. Arrangement for the photographic recording of electric wave currents.
Apr. 2, 1920	Vogt, Massolle, Engl	356,499. Amplifying arrangement, especially for telephone purposes.
Apr. 2, 1920	Massolle, Vogt, Engl	498,345. Coupling circuit for electrostatic telephone with low frequency amplifiers.
May 23, 1920	Engl, Massolle, Vogt	362,370. Photoelectric organ for the reception, transmission and reproduction of photographically received sounds.
May 23, 1920	Engl, Vogt, Massolle	371,347. Electrode for photoelectric cells.
May 23, 1920	Massolle, Vogt, Engl	377,921. Electro-static loud speaking telephone.
May 23, 1920	Vogt, Massolle, Engl	387,058. Device for phonographs for uniform drive of the linear phonogram carrier.

Defendants' Exhibit No. 150

Filing Date	Patentees	Number and Title
May 23, 1920	Massolle, Engl, Vogt	389,234. Device for receiving and reproducing sound, especially sound films.
June 23, 1920	Vogt, Engl, Massolle	351,313. Glow tube, especially for the photographic recording of alternating currents.
June 23, 1920	Engl, Massolle, Vogt	351,814. Arrangement for making optically visible or registering alternating current waves.
June 23, 1920	Engl, Vogt, Massolle	351,889. Gas discharge device with capillary discharge path for the photographic recording of electrical frequencies on a light-sensitive carrier.
June 23, 1920	Vogt, Massolle, Engl	351,956. Gas discharge means for controlling electrical currents under the control of sound variations.
June 23, 1920	Vogt, Engl, Massolle	368,025. Apparatus for the control of electric currents by means of sound variations. (Addition to Patent 350,500.)
June 23, 1920	Massolle, Vogt, Engl	370,214. Device for the photographic recording of sound waves by means of swinging mirrors.
June 23, 1920	Vogt, Massolle, Engl	371,274. Driving apparatus for picture bands with images.
June 23, 1920	Massolle, Vogt, Engl	375,941. Device for the reproduction of talking films, employing amplifier tubes.
June 23, 1920	Vogt, Massolle, Engl	391,566. Device for the electric recording of sound waves on disc records, cylinder records, films, or the like.
Sept. 9, 1920	Massolle, Vogt, Engl	359,995. Differential coupling in which, in accordance with Patent 353,644, the amplitude of high frequency oscillations is controlled by low frequency oscillations by means of current phase displacements in two differential circuits. (Addition to Patent 353,644.)

Filing Date	Patentees	Number and Title
Sept. 9, 1920	Massolle, Engl, Vogt	434,511. Electro-static loud speaking telephone.
Oct. 6, 1920	Massolle, Engl, Vogt	377,920. Magnetic telephone for loud speaking purposes.
Oct. 31, 1920	Massolle, Vogt, Engl	368,899. Stretched diaphragm for electro-static telephones.
Nov. 2, 1920	Massolle, Vogt, Engl	368,900. Diaphragm for electro-static telephone.
Nov. 13, 1920	Massolle, Vogt, Engl	359,769. Telephone arrangement for motion picture theatre for sound and picture operation.
Nov. 23, 1920	Massolle, Engl, Vogt	362,028. Arrangement for photographic recording of sound waves on a light-sensitive carrier.
Nov. 26, 1920	Massolle, Vogt, Engl	397,868. Device and circuit for the control of high frequency waves by means of low frequencies.
Dec. 4, 1920	Massolle, Vogt, Engl	368,287. Arrangement for electro-static telephone.
Dec. 4, 1920	Massolle, Vogt, Engl	424,130. Electro-static telephone.
Dec. 25, 1920	Engl, Vogt, Massolle	351,878. Discharge gap with photo-electric sensitivity for sound transmission, especially for purposes of the talking film.
Dec. 25, 1920	Engl, Massolle, Vogt	416,827. Photoelectric organ for quickly changing light variations for sound transmission in an electro-optical manner.
Jan. 6, 1921	Vogt, Massolle, Engl	426,780. Method for electric transmission of acoustic manifestations.
Jan. 12, 1921	Massolle, Vogt, Engl	376,321. Intermittently operating feed mechanism for cinematographs.
Jan. 12, 1921	Massolle, Engl, Vogt	377,079. Cinematograph. (Addition to Patent 376,320.)
Jan. 12, 1921	Massolle, Vogt, Engl	377,080. Sprocket wheel for cinematographs. (Addition to Patent 376,320.)
Jan. 21, 1921	Massolle, Engl, Vogt	392,126. Amplifier tubes with flat or flattened cathodes.

Filing Date	Patentees	Number and Title
Feb. 6, 1921	Massolle, Engl, Vogt	389,847. Feed mechanism for cinematograph apparatus.
Feb. 19, 1921	Massolle, Engl, Vogt	423,877. Arrangement for vacuum tubes with light source as an ohmic resistance.
Feb. 19, 1921	Massolle, Vogt, Engl	437,541. Telephone diaphragm of ring form. (Addition to Patent 434,511.)
Feb. 20, 1921	Massolle, Vogt, Engl	391,229. Differential circuit connection.
Mar. 25, 1921	Engl, Massolle, Vogt	363,918. Arrangement for the distortion-free recording of sounds on a light-sensitive carrier.
Mar. 25, 1921	Massolle, Engl, Vogt	369,075. Gas discharge tube with cathodic glow light for the recording of electric oscillations.
Mar. 25, 1921	Massolle, Vogt, Engl	389,318. Arrangement for phonographs with linear phonogram carriers. (Addition to Patent 387,058.)
Mar. 25, 1921	Engl, Vogt, Massolle	392,118. Cathode ray tubes for the distortion-free recording of electric frequencies.
Apr. 10, 1921	Massolle, Vogt, Engl	389,319. Arrangement for phonographs with linear phonogram carriers. (Addition to Patent of Addition 389,318.)
Apr. 15, 1921	Vogt, Massolle, Engl	368,383. Method of producing films with image and photographed sound.
May 19, 1921	Vogt, Engl, Massolle	366,266. Arrangement for the suppression of air currents with a process for the control of electrical current through sound forces.
May 19, 1921	Vogt, Massolle, Engl	368,288. Arrangement for effecting the control of electric currents by means of sound variations.
May 25, 1921	Massolle, Engl, Vogt	390,180. Electric driving device for linear phonogram carriers.
July 14, 1921	Vogt, Massolle, Engl	386,370. Sound amplifying arrangement, especially for the amplification of sound within larger spaces.

Filing Date	Patentees	Number and Title
July 24, 1921	Massolle, Engl, Vogt	391,549. Protective connection for the suppression of the reaction effect between two or more amplifier tubes.
Aug. 11, 1921	Vogt, Engl, Massolle	384,028. Device for converting electric energy into motion.
Nov. 30, 1921	Massolle, Vogt, Engl	426,839. Telephone diaphragm.
Jan. 24, 1922	Massolle, Vogt, Engl	389,317. Arrangement for phonographs with linear phonogram carrier, more particularly for the purposes of talking films. (Addition to Patent 387,058.)
Jan. 24, 1922	Engl, Vogt, Massolle	391,567. Device for the recording of sound waves. (Addition to Patent 391,566.)
Jan. 31, 1922	Massolle, Engl, Vogt	381,973. Control device for drive shafts of sound films.
Feb. 16, 1922	Massolle, Vogt, Engl	382,578. Continuous copying machines.
Feb. 18, 1922	Vogt	385,451. Toy.
Feb. 22, 1922	Massolle, Vogt, Engl	389,782. Sound film recording apparatus.
Mar. 1, 1922	Massolle, Engl, Vogt	369,312. Circuit arrangement for photo cell.
Mar. 1, 1922	Massolle, Engl, Vogt	396,124. Arrangement for reproducing sound picture films.
Mar. 4, 1922	Massolle, Vogt, Engl	393,254. Device for the back coupling of amplifiers in a negative sense.
Mar. 31, 1922	Engl, Vogt, Massolle	395,855. Device for the photographic recording of sound vibrations on talking machine records by means of glow light.
June 10, 1922	Vogt, Engl, Massolle	368,498. Housing for apparatus for the recording of sound picture films.
June 10, 1922	Engl, Vogt, Massolle	389,598. Method for development for film bands with sound striations.
Aug. 5, 1922	Engl, Massolle, Vogt	430,368. Electrode arrangement for microphone with an ionized gas stream.

Filing Date	Patentees	Number and Title
Feb. 18, 1923	Engl	386,334. Arrangement for measuring Köntgen rays.
July 22, 1923	Engl, Massolle, Vogt	423,492. Method for the transmission of sound recorded on discs, cylinders, bands, etc., for talking machines.
Mar. 11, 1925	Engl, Vogt, Massolle	436,207. Method and arrangement for the photographic recording of sound waves.
Mar. 11, 1925	Massolle, Engl, Vogt	463,536. Arrangement for amplification of electrical potentials and current by means of discharge tubes.
Mar. 11, 1925	Massolle, Engl, Vogt	463,937. Sub-divided diaphragm for capacitive telephones.
Mar. 11, 1925	Massolle, Vogt, Engl	498,438. Circuit arrangement for capacitive telephone galvonically coupled with an amplifier tube.
Apr. 8, 1925	Massolle	474,492. Electro-static loud speaker. (Addition to Patent 434,511. Earlier Patent of Addition 437,541.)
July 8, 1925	Engl	436,208. Method and arrangement for the recording of sound waves on a light-sensitive carrier.
Aug. 13, 1925	Engl, Massolle	448,473. Arrangement for the recording of sounds.
Sept. 4, 1925	Massolle	487,319. Arrangement for producing marks photographically on sound picture films.
May 8, 1926	Vogt	500,302. Fixed perforated opposing electrode for electro-static sound reproduction or recording apparatus.
May 20, 1926	Massolle	475,430. Electro-static telephone.
June 5, 1926	Vogt	494,221. Arrangement for the conversion of acoustic vibrations electrically and reversed by means of electro-static field.

Filing Date	Patentees	Number and Title
June 12, 1926	Vogt	499,059. Method of producing discs provided with perforations, especially for capacitive surfaces of electro-static telephones and microphones.
July 21, 1926	Vogt	499,060. Electro-static sound recording and reproducing arrangement.
June 4, 1927	Vogt	507,541. Condenser telephone.
Nov. 3, 1927	Vogt	511,230. Sound device of the condenser type, with spring mounted pressure ring for controlling the diaphragm tension.
Jan. 14, 1928	Vogt	531,299. Method of producing fixed condenser plates for electro-static telephones and microphones.
June 24, 1928	Vogt	529,868. Sound mark carrier for sound producer.
Sept. 5, 1928	Vogt	533,262. Capacitive surfaces for sounding condensers.
Oct. 6, 1928	Vogt	500,370. Differentially working condenser telephone.
Oct. 18, 1928	Engl	500,871. Arrangement for sound reproduction by means of sound films.
Feb. 12, 1929	Engl	532,720. Slit aperture for arrangements for the design or production of light intensity changes.
Apr. 6, 1929	Vogt	490,108. Arrangement for maintaining constant the tension of a diaphragm, especially in connection with electro-static loud speaker telephones and microphones.
Nov. 17, 1929	Vogt	512,645. Method for insulating the perforated plates of sound devices of the condenser type.
Dec. 14, 1929	Vogt	536,281. Sound device of the condenser type, with dielectric layer for insulating both surfaces one from another.

Filing Date	Patentees	Number and Title
Jan. 24, 1930	Vogt	521,471. Method for insulating the perforated plates of sound devices of the condenser type. (Addition to Patent 512,645.)
	UNITED STATES PATENTS.	
Mar. 30, 1921	Massolle, Vogt, Engl	1,597,323. Differential modulator.
Apr. 4, 1921	Vogt, Engl, Massolle	1,534,148. Sound translating apparatus.
Apr. 4, 1921	Engl, Massolle, Vogt	1,557,678. Acoustic cinematographic apparatus.
Apr. 4, 1921	Massolle, Vogt, Engl	1,558,032. Arrangement for acoustic cinematography.
Apr. 4, 1921	Massolle, Engl, Vogt	1,566,413. Means for recording sound waves.
Apr. 4, 1921	Massolle, Vogt, Engl	1,587,786. Electron tube.
Apr. 4, 1921	Engl, Vogt, Massolle	1,590,185. Light source and light-sensitive coating for phono-cinematography.
Apr. 4, 1921	Vogt, Engl, Massolle	1,628,377. Means for controlling amplitude of high frequency oscillations.
Apr. 4, 1921	Massolle, Vogt, Engl	1,630,753. Amplifier.
Nov. 28, 1921	Massolle, Vogt, Engl	1,550,381. Electro-static telephone.
Mar. 20, 1922	Massolle, Engl, Vogt	1,555,301. Amplifier coupling.
Mar. 20, 1922	Massolle, Engl, Vogt	1,634,201. Glow discharge tube.
Mar. 20, 1922	Vogt, Massolle, Engl	1,713,726. Device for phonographs with linear phonogram carrier.
Mar. 29, 1922	Vogt, Massolle, Engl	1,825,598. Process for producing combined sound and picture films.
July 18, 1924	Engl, Massolle, Vogt	1,555,281. Method of recording sound by transference.
Mar. 26, 1925	Massolle, Vogt, Engl	Re 17,448. Telephone.
Mar. 26, 1925	Massolle, Vogt, Engl	1,585,333. Telephone.
Aug. 3, 1925	Massolle	Re 17,256. Electro-static telephonic instrument for transmitting or receiving purposes.

Filing Date	Patentees	Number and Title
Aug. 3, 1925	Massolle	Re 17,257. Electro-static telephone.
Aug. 3, 1925	Massolle	1,582,848. Electro-static telephone.
Aug. 3, 1925	Massolle	1,609,760. Electro-static telephonic instrument for transmitting or receiving purposes.
Mar. 3, 1927	Engl	1,688,008. Holding device.
Sept. 6, 1927	Vogt	1,782,278. Vibrating condenser.
Feb. 26, 1929	Vogt	1,816,992. Sounding condenser.
Oct. 2, 1929	Engl	1,851,164. Sound translation.

CANADIAN PATENTS.

Sept. 1, 1921	Vogt, Massolle, Engl	225,250. Differential connection for electric frequencies.
Sept. 1, 1921	Vogt, Engl, Massolle	230,118. Method for the control of electric currents by power of sound.
Sept. 1, 1921	Massolle, Vogt, Engl	250,784. Arrangement for the distortion-free intensification of sounds and tones for the purposes of acoustic kinematography.
Sept. 1, 1921	Vogt, Engl, Massolle	283,946. Optical acoustic apparatus.
Jan. 14, 1925	Vogt, Engl, Massolle	259,221. Sound records.
Aug. 12, 1925	Massolle	261,378 (Re-issued as 306,424). Electro-static telephone.
Aug. 12, 1925	Massolle	264,685. Electro-static telephonic instruments for transmitting or receiving purposes.
Jan. 11, 1928	Vogt	293,139. Vibrating condenser.
Oct. 3, 1928	Vogt	297,752. Sounding condenser.
Feb. 19, 1929	Vogt	301,149. Sounding condenser.
May 15, 1930	Massolle	306,424. Electro-static telephone.

DEFENDANTS' EXHIBIT NO. 151.

UNITED STATES DISTRICT COURT FOR THE MIDDLE DISTRICT OF PENNSYLVANIA

U. S. DISTRICT COURT
M. D. PENN.
DEFT. EX. H-1

AMERICAN TRI-ERGON CORPORATION AND TRI-ERGON HOLDING A.G.

vs.

ALTOONA PUBLIX THEATRES, INC.

AMERICAN TRI-ERGON CORPORATION AND TRI-ERGON HOLDING A.G.

vs.

WILMER AND VINCENT CORPORATION AND LOCUST REALTY ESTATE COMPANY

In Equity No. 971

Carl W. Mitman being first duly sworn, deposes and says:

That, I am Head Curator, Department of Arts and Industries, of the U. S. National Museum under the Smithsonian Institution, located in the City of Washington, District of Columbia, and I have been in charge of the Engineering Collections of the United States National Museum since July 1, 1919.

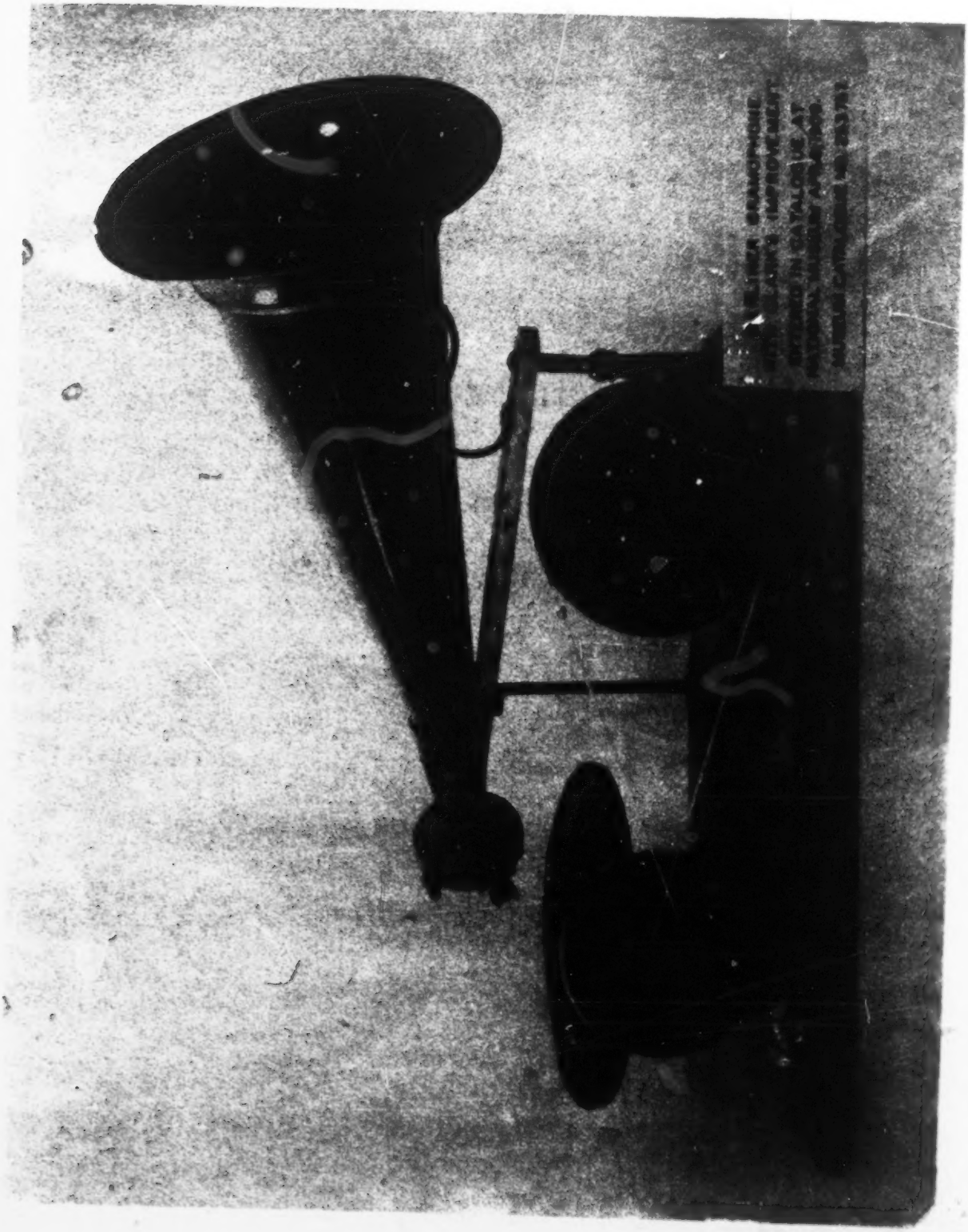
That, I personally examined prior to March 24, 1921 the Berliner Gramophone with Clark's Improvement, Museum Catalog No. 253,757, and that the attached photographs are a true copy of the said Berliner Gramophone and were made by the Museum prior to the date that the said Berliner Gramophone was removed from the Museum by a representative of the defendants.

That, these photographs show the said Berliner Gramophone to be in the same condition as the said Gramophone was prior to March 24, 1921.

Carl W. Mitman

Subscribed and sworn to before me
this 26th day of June A. D. 1933.

Andrew E. Rummel
Notary Public
My Commission expires Sept 11-1935



BERLINER GRAMOPHONE
WITH CLARK'S IMPROVEMENT.
ENTERED IN CATALOGUE AT
NATIONAL MUSEUM APR 6, 1900
MUSEUM CATALOGUE NO. 283757

DEFENDANTS' EXHIBIT NO. 152.

U. S. DISTRICT COURT
M. D. PENN.
DEFT. EX. 152

UNITED STATES DISTRICT COURT FOR THE MIDDLE DISTRICT OF PENNSYLVANIA

AMERICAN TRI-ERGON CORPORATION AND TRI-ERGON HOLDING A. G.	:	
vs.	:	
ALTOONA PUBLIX THEATERS, INC.	:	In Equity
AMERICAN TRI-ERGON CORPORATION AND TRI-ERGON HOLDING A.G.	:	No. 971
vs.	:	
WILMER AND VINCENT CORPORATION AND LOCUST REALTY ESTATE COMPANY	:	

I, Carl W. Mitman, being first duly sworn, depose and say:

I am Head Curator, Department of Arts and Industries of the U. S. National Museum under the Smithsonian Institution, located in the City of Washington, District of Columbia, and I have been in charge of the engineering collections of the United States National Museum since July 1, 1919.

I was Curator of the Division of Engineering of the U. S. National Museum when the machine known as Berliner Gramophone, Museum Catalog No. 307,204, was received by the Museum on January 14th, 1921, and when the machine known as Bell and Tainter machines bearing Museum Catalog Nos. 287,660 and 287,653 were catalogued by the Museum on November 30th, 1920. I received the Berliner Gramophone on the above said date and personally examined it on that date. I personally examined the said Bell and Tainter machines on November 30, 1920 when they were catalogued. I have examined the said three machines today and have compared them carefully with copies of the photographs thereof which were made by

the Museum and were recently certified by the Smithsonian Institution and furnished to a representative of defendants in these suits. The said three machines are now, and were at the time the photographs were taken and certified, in exactly the same condition that they were on the dates they were received and catalogued by the Museum.

Carl W. Mitman

Subscribed and sworn to before me
this 16th day of June A. D. 1933.

Andrew E. Sommerness
Notary Public
My Commission expires Sept 17-1933

M. D. PENN.
DEFT. EX. 113 **DEFENDANTS' EXHIBIT NO. 153.**

UNITED STATES DISTRICT COURT FOR THE MIDDLE DISTRICT OF PENNSYLVANIA

AMERICAN TRI-ERGON CORPORATION AND TRI-ERGON HOLDING A.G. :

vs. :

ALTOONA PUBLIX THEATERS, Inc. :

In Equity

No. 971

AMERICAN TRI-ERGON CORPORATION AND TRI-ERGON HOLDING A.G. :

Vs.

WILMER AND VINCENT CORPORATION AND LOCUST REALTY ESTATE COMPANY :

Carl W. Hitman being first duly sworn, deposes and says:

That the Bell and Tainter machine identified by Museum No. 287,660 referred to in another affidavit which I executed today had on it when received by the Museum, the waxed paper record strip which may be seen in the annexed photographs made by the Museum. This wax paper record is in the same condition that it was when received, except for such deterioration as has resulted from the passage of the intervening years.

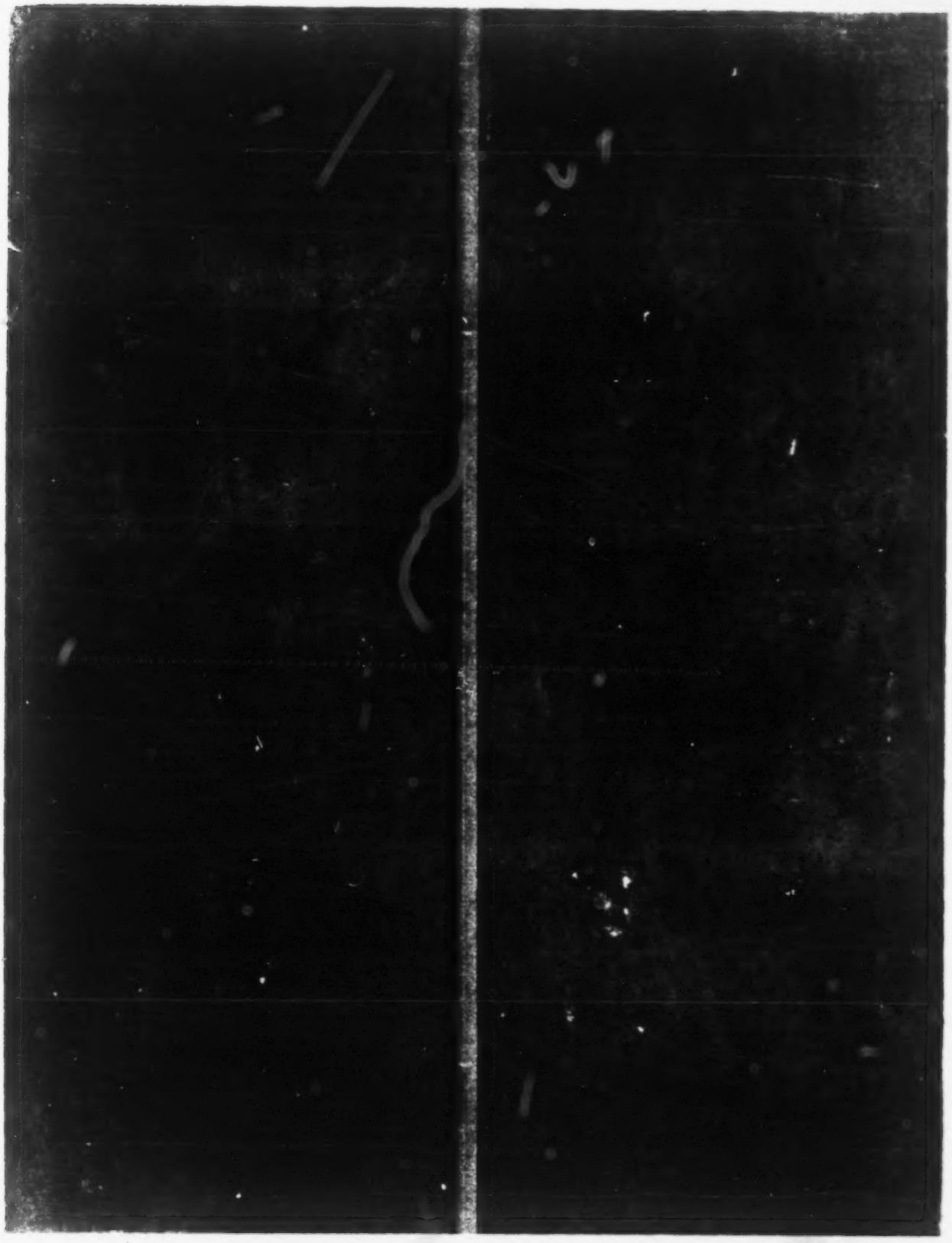
That, the following is an accurate description of the record strip: The strip is made of paper, coated with wax, and is approximately 80 feet long. The paper itself is approximately .008 inches thick, disregarding the wax. There is more wax on the side of the paper on which the stylus tracks. It is apparent that the major portion of the wax was removed from the other side of the strip, probably while the paper strip was being coated. The wax on the stylus side of the record is thickest at the middle,

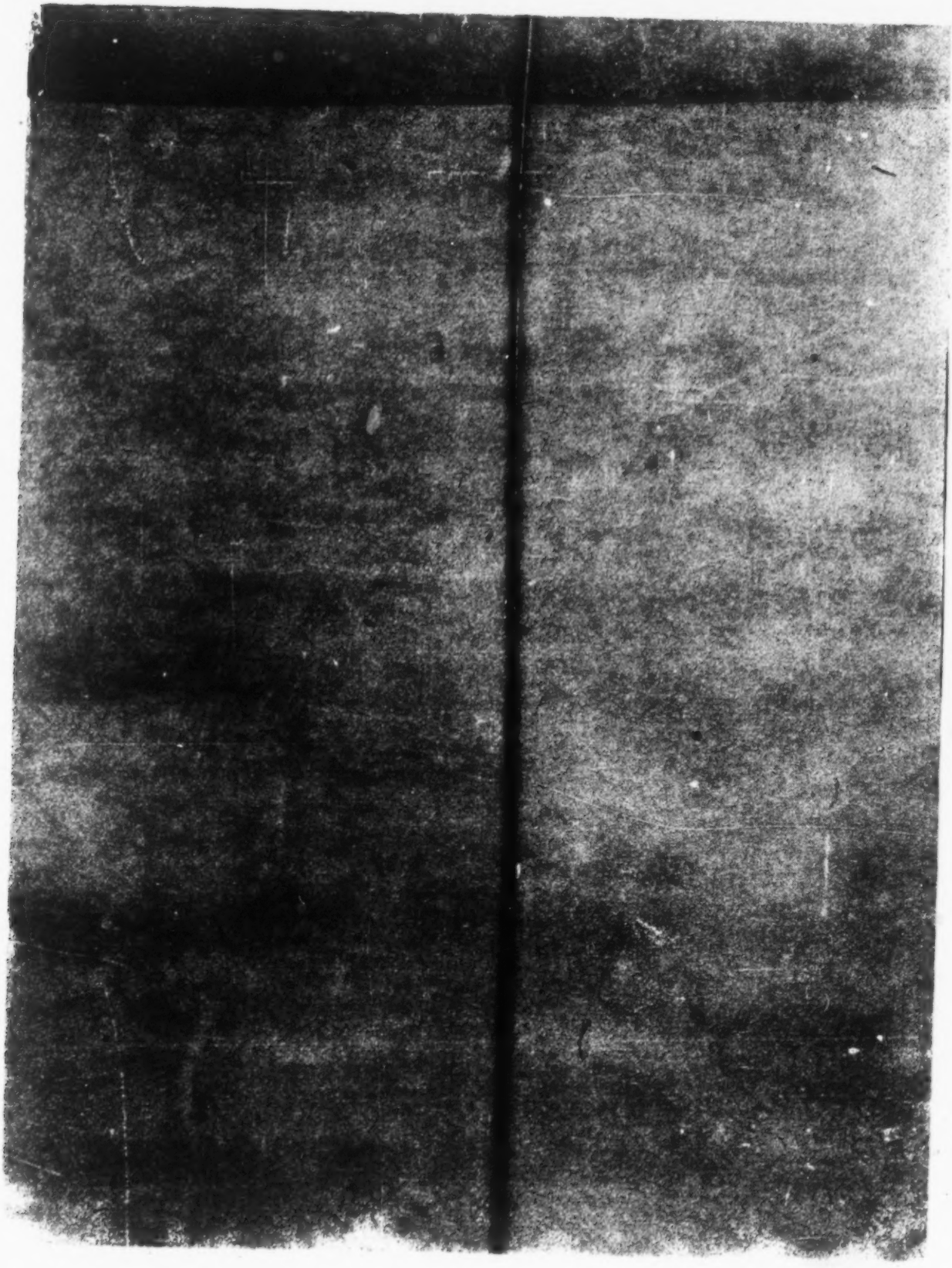
possibly attained by the natural accumulation of hot wax during its hardening while the paper strip was suspended horizontally. The wax on the stylus side of the record strip contains a single groove cut in the center. The groove shows irregularities under a magnifying glass, which irregularities simulate a modulated sound record. The strip is very uniform and smooth throughout and the groove is fairly uniform in depth. The overall thickness of the paper and wax at the center of the record strip is approximately .021 inches in thickness. Close to the edge the waxed strip is approximately .012 inches in thickness. The groove is approximately .003 to .004 inches in depth. There is no general cracking or roughness of the wax.

Carl O. Mitman

Subscribed and sworn to before me
this 26th day of June A. D. 1933.

Andrew E Lemmon
Notary Public
My Commission expires Sept 17-1934





DEFENDANTS' EXHIBITS NOS. 154-A and 154-B.

Records Introduced Under Capps Stipulation, Relating to Lightweight Records Made by Columbia Phonograph Co., in 1906.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 155.

Edison Triumph Machine Identified by Witness Burt.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 156.

Copies of Sheets of Notebook Identified by Witness Engl.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 157.

File History and Contents of Cawley Patent No. 1,710,677, Granted April 23, 1929.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 158.

File History and Contents of Cawley Patent No. 1,825,440.

(Physical Exhibit.)

DEFENDANTS' EXHIBIT NO. 159-A.

DEFENDANTS' EXHIBIT NO. 159-B.

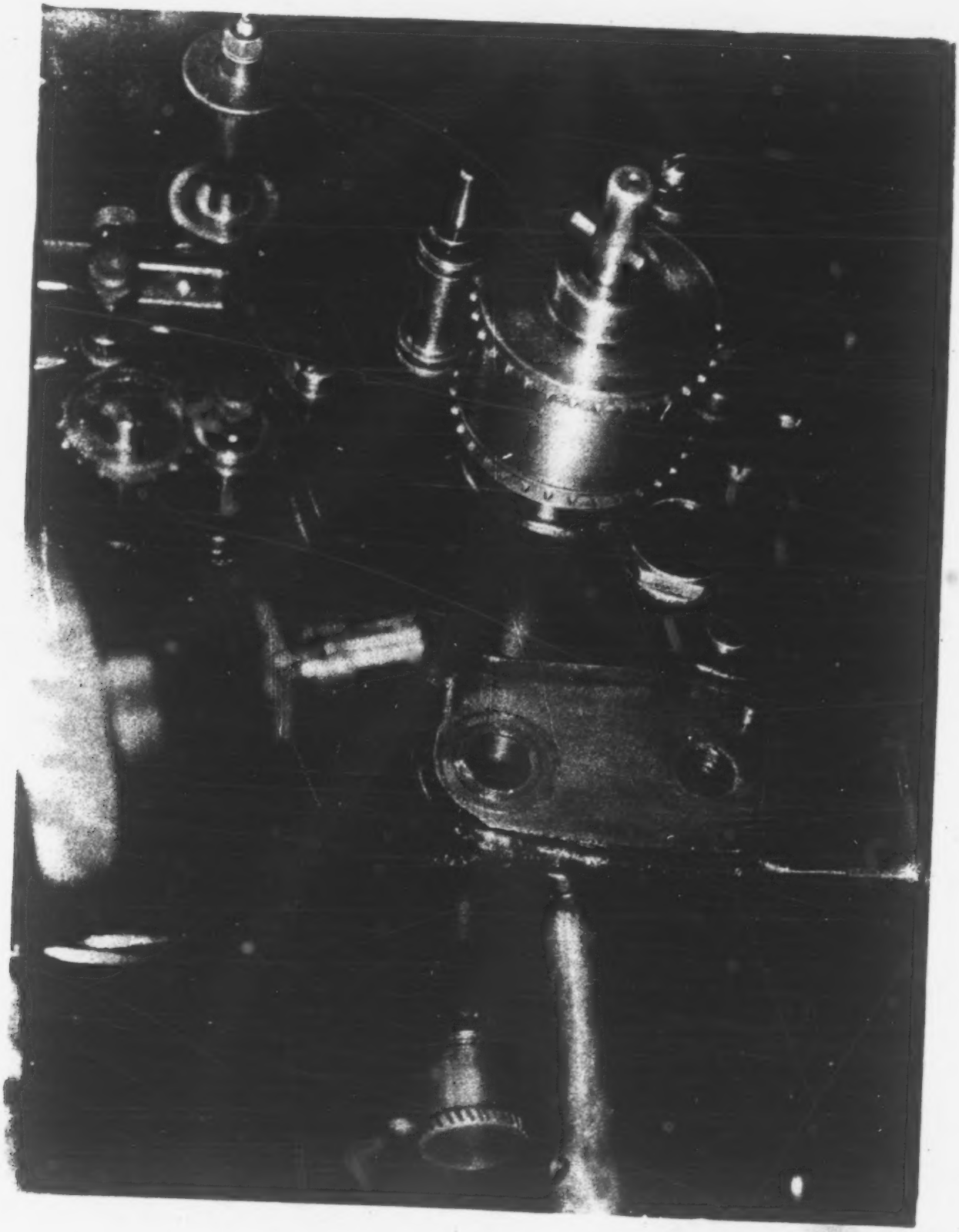
DEFENDANTS' EXHIBIT NO. 159-C.

159 C

DEFENDANTS' EXHIBIT NO. 159-D.

DEFENDANTS' EXHIBIT NO. 159-E.

DEFENDANTS' EXHIBIT NO. 159-F.



DEFENDANTS' EXHIBIT NO. 159-G.